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PHYTOPLANKTON OF ESQUIMALT LAGOON, BRITISH COLUMBIA: COMPARISON WITH WEST VANCOUVER ISLAND COASTAL AND OFFSHORE WATERS

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ABSTRACT

Waters, R.E., L.N. Brown and M.G. Robinson. 1992. Phytoplankton of Esquimalt Lagoon, British Columbia: comparison with west Vancouver Island coastal and offshore waters. Can. Tech. Rep. Hydrogr. Ocean Sci. 137: 59 p.

The results of an eight-month taxonomic study of the phytoplankton of Esquimalt Lagoon, British Columbia, are presented, and compared with previous data on Esquimalt Lagoon, as well as with relevant data obtained from the adjacent coastal and offshore regions. Identifications in the majority of cases were made with the aid of light microscopy only, with some exceptions for which electron microscopy was also used to show scale or diatom valve structure. This has restricted to some extent the identification of small species, nanoflagellates in particular. Drawings and photomicrographs accompany the numerical data, to illustrate interesting or unidentified species. In general, Esquimalt Lagoon was found to be highly productive, with respect to both biomass and species diversity, the latter including a range of freshwater to oceanic forms.

Keywords: phytoplankton, distributions, taxonomy, Esquimalt Lagoon

RÉSUMÉ

Waters R.E., L.N. Brown and M.G. Robinson. 1992. Phytoplankton of Esquimalt Lagoon, British Columbia: comparison with west Vancouver Island coastal waters. Can. Tech. Rep. Hydrogr. Ocean Sci. 137: 59 p.

Les résultats de l'étude taxonomique de huit mois sur les phytoplanctons de la Lagune d'Esquimalt, Colombie Britannique, sont ici présentés et comparés avec les résultats précédents, de même qu'avec des données relatives, obtenues de régions côtières adjacentes et en haute mer. Les identifications dans la majorité des cas furent réalisées grâce aux rayons microscopiques seulement, sauf exceptions faites, d'électrons microscopiques qui furent aussi utilisés afin de montrer les écailles et les structures des valves diatomiques. Ce procédé a restraint, en quelque sorte, l'identification d'espèces minuscules, en particulier les nanoflagellés. Des dessins et des photomicrographes accompagnent les données numériques et illustrent les espèces intéressantes et celles non-identifiées. En général, la Lagune d'Esquimalt se trouve en productivité intense, en ce qui concerne la diversité des espèces et leur biomasse, la première incluant un nombre de formes provenant de l'océan comme de l'eau douce.

Mots-clés: phytoplanctons, distributions, taxonomie, Lagune d'Esquimalt

Previous reports on Esquimalt Lagoon have focussed on a recurring red tide (Watanabe & Robinson, 1979; Robinson & Brown, 1983; Voltolina & Robinson, 1984; Voltolina et al., 1985; Robinson & Brown, 1991), as well as zooplankton (Robinson & Brauser, 1979), bacteria (Williams, 1979; Watanabe & Robinson, 1980), and the lagoon's physical properties (Scrimger, 1960; Mehta, 1974). This report provides a taxonomic summary of phytoplankton species and their occurrence, together with illustrations of interesting or unidentified species. It is hoped that it will serve as an aid to identification for further lagoon studies, and may also be of use for adjacent waters.

The major focus for this report is a taxonomically detailed, eight-month study conducted in March to October, 1989. Additional, less detailed, information for Esquimalt Lagoon was obtained in 1978 to 1980; where possible this data has been used to enhance the information collected in 1989. Comparisons have been made with some species distributions and patterns for the west Vancouver Island coastal region and for offshore areas along line P (Fig. 1). Coastal and 1984 and 1987 line P data are used with the permission of J.R. Forbes, Ocean Ecology Division, Institute of Ocean Sciences (IOS), Sidney, B.C.; line P data collected from 1973 to 1977 are included with the permission of F.J.R. Taylor, Department of Oceanography, University of British Columbia (UBC), Vancouver, B.C.

METHODS

Samples from Esquimalt Lagoon samples were collected, once a month from March to October 1989, from station B, located approximately mid-lagoon (Fig. 1A). Samples were integrated from the surface to 0.5m off the bottom, or approximately 0-3m, using a collection tube which consisted of a length of Tygon tubing which was lowered to depth, stoppered at the surface, then withdrawn and dispensed into a 1L, dark polyethylene bottle. The total sample volume was usually near 1000 mL. In the May 1978 to December 1980 study, samples were collected in a similar manner, from stations A, B and C (Fig. 1A), four days per month, all year round.

UBC line P samples (Fig. 1C) were collected by IOS under the direction of J. Garrett. Twenty-six Canadian Weathership cruises from 1973-77 provided at least 2 data sets for each month of the year. Samples were collected from surface waters, from the ship's onboard circulating seawater system. IOS line P data were collected in May 1984 and 1987, from the areas of stations P and P3-4 only. These were drawn by Niskin bottle and surface bucket respectively.

Coastal samples were collected during 2 to 3 IOS summer cruises per year from 1980-87 and 1989, providing a total of 802 samples (Fig. 1B). These were drawn from a variety of depths by Niskin bottle, and usually included at least one sample per station from the surface layer (0-15m). Occasional surface samples were collected by bucket, and additional samples were taken from the ship's onboard seawater system.

Samples were generally preserved with Rodhe's (acid) Lugol's iodine and examined by inverted light microscope. Utermohl's (neutral) iodine was used for coccolithophorid counts. Except for the IOS work, parallel live samples were examined on most occasions.

The 1978-80 Esquimalt Lagoon counts were obtained from transect counts in 2.2, 10 or 50 ml settling chambers, using magnifications of 100x, 200x and 320x. The number of cells or chains actually counted was usually between 30 and 100 for each of the 10 most abundant taxa present. In general only monthly maxima for each taxon are reported, and only where that taxon was present in several samples and a buildup in numbers was seen, as opposed to a random occurrence.

The April and July to October 1989 Esquimalt Lagoon samples and the IOS samples were counted in 2.2, 10 or 50 ml chambers at magnifications of X10, X300, and X500, while the UBC samples were counted at X7, X300, and X800. The entire chamber was counted, usually at X300, for all species which required it, either because of an uneven distribution resulting from the sinking dynamics of their cell shapes or chain formations or where numbers of the most abundant species were below 100. Parallel transects spread out across the chamber were counted for evenly distributed species present in high concentrations or for small species requiring high magnification. The subsample volumes were set so that actual counts of 50-200 cells or chains of most species present could be made. Counts of 100-200 cells or chains of each of the 20 most abundant taxa present were normal and gave an overall sample error of less than $\pm$ 5% as a rule, though the individual taxon error was usually 15-20% on repeat counts. Twenty of the 1978-1980 July-September counts were rechecked with this method and found to duplicate the original figures quite acceptably. Cell numbers are given as numbers per 10 ml of original sample.

The March, May and June 1989 lagoon data are rough estimates of species abundances only.

Species identifications were generally by light microscope as described above, but in some cases additional means were required, particularly for very minute species. In these cases, a number of techniques were employed, including, as needed, isolation by micropipette and cultivation in growth media, followed by transmission electron microscopy (TEM) or scanning electron microscopy (SEM). Material for shadowcasting (TEM) was fixed with osmium tetroxide vapour and shadowed with gold palladium. Material for SEM was fixed with Lugol's iodine and/or osmium tetroxide, critically point dried and coated with gold palladium. The generally poor quality of the micrographs (Figs. 10-12) is due to their having been produced as preliminary aids to identification only; however they are included where useful to show details not visible with light micrscopy.

RESULTS

Esquimalt Lagoon is a shallow (maximum depth ca. 4.0m at high tide), almost entirely landlocked body of water which receives fresh stream water on its landward sides and marine

water from Juan de Fuca Strait at its mouth (Fig. 1A). Surface temperatures range from less than 1°C in the winter to over 20°C in the summer, and from 4°C to 12°C at the bottom; salinities generally fall in the range 29‰ to 32‰, except in the top few centimeters where salinity occasionally ranges below 20‰. The lagoon and its properties are described more fully by Watanabe and Robinson (1979, 1980).

Line P consists of a row of sampling stations which extend from the mouth of Juan de Fuca Strait offshore toward station P, located at 50°N 145°W (Fig. 1C). In 1973-77, when the majority of the line P samples were taken, there were a total of 13 stations, from P1 to P12 and P, as shown in Figure 1C. Thirteen additional stations were added in later years, and the original stations were renumbered, but for the purposes of this report, the original station numbers have been retained. As will be seen in later sections, station P4 seemed to mark a cut-off point in the distributions of many phytoplankton species. Many of the coastal species of diatoms in particular did not occur beyond station P4, while many oceanic species were most abundant at stations P5-P. This was not always the case, however, likely due to the formation of plumes of surface water drawn offshore by currents (Denman et al., 1989, Fig. 7; Denman et al., in preparation).

CENTRIC DIATOMS

Skeletonema costatum

This common species was present in the lagoon at all times of the year, but appeared to form blooms three times in an average year (Fig. 2). These blooms occurred at any time of the year but most often in spring, summer and autumn. This was also found to be the case at stations P1-P4. The highest lagoon numbers nearly always coincided with coastal blooms of the common neritic Chaetoceros spp. (Table 1, Group *) or Thalassiosira spp. (p. 5-6 Group I), though these latter two groups did not always bloom together. In fact, they often did not coincide in the coastal waters as a whole.

Chaetoceros

The 1989 Esquimalt Lagoon figures for Chaetoceros are summarized in Table 1, with the most common species from 1978-80 indicated by an asterisk (*). In 1989 there were apparently two blooms of these common "Group *" species. The 1978-80 data indicate Chaetoceros Group * blooms as follows:

1978		1979		1980	
May	2 500	Mar-Apr	140 000	Feb-Mar	50 000
July-Aug	35 000	May-June	120 000	May-July	30 000

Individual species summer maxima (1978-80) for Group * species were:

C. constrictum and/or vanheurckii[1]	120 000
C. sociale	71 000
C. debile	43 000
C. crucifer	27 000
C. diadema	19 000
C. compressum	12 000
C. radicans	7 800
C. laciniosum	4 000
C. didymum	2 000

In addition these species (given with their 1978-80 summer maxima), although not abundant in 1978-80, are common in these coastal waters:

C. decipiens	1 800
C. septentrionale	1 200
C. simile	1 000

Between November and February (1978-80), and between blooms, the total abundance of the above Chaetoceros species in the lagoon was usually less than 2 000, C. debile being dominant in winter.

In the open coastal water, blooms of these species rarely produced numbers of the magnitude seen in the lagoon. The open coastal blooms were usually dominated by C. debile, C. radicans and C. compressum, and generally occurred from May to September.

Small (<5 μm), single-celled Chaetoceros spp. were present in the lagoon year-round in 1978-80, with a summer maximum of 1 000 000 and a winter maximum of 320. Although these were not identified at that time, it is likely that they consisted mainly of Chaetoceros sp. H (Fig. 5.1). This species seldom appeared in the open coastal water samples. Chaetoceros sp. Gi (Fig. 4.8) was the most common species at stations P1-P4. It formed a heavy bloom with sp. B (Fig. 4.2) and a single form of C. simile (Fig. 4.10) in Barkley Sound in June 1989, a situation in which it can be difficult to discriminate species. Chaetoceros sp. K (Fig. 5.3) has been seen by Buchanan (1966) in Indian Arm but was not seen in any of our open water samples. Chaetoceros sp. L (Fig. 5.4) has only been seen by us once before, as a bloom with Thalassiosira weissflogii in very brackish water at the head of Alberni Inlet, and Chaetoceros sp. J (Fig. 5.2) was only seen in the lagoon.

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[1]These species can be difficult to differentiate unless spores are present.

Discoid centrics

The occurrence of drum-shaped centric diatoms, mainly Thalassiosira, in Esquimalt Lagoon, is shown in Fig. 3. As can be seen, there were a number of different species. In 1978-80 these diatoms were incompletely identified, and following are included discussions of the species which were most likely present. The IOS work has shown that the most common coastal and inshore species can be grouped as follows (the numbers shown represent the frequency of sightings--not necessarily abundance--of each species in the open coastal waters):

GROUP I	T. nordenskioldii	1
	T. pacifica	1
(diameter generally	T. anguste-lineata	2
within 15-60 μm	T. rotula	2
except T. angstii	T. mendiolana	3
which is ≥60 μm)	T. aestivalis	3
	T. sp. 1[2] (Fig. 10.1)	4
	T. lineata	4
	T. angulatum	4
	T. tenera	4
	T. eccentrica	4
	T. angstii	5
	T. leptopus	5
	T. symmetrica	5
	T. baltica	inshore brackish only
	T. incerta	inshore brackish only
	T. weissflogii	inshore brackish only

GROUP II	T. conferta	3.5-23 μm (Figs. 6.9, 10.2)	1
	Cyclotella sp. 2	4-10 μm (Figs. 6.8, 10.3)	2
(diameter	T. guillardii	4-14 μm (Fig. 10.4)	2
generally	T. pseudonana	4-9 μm (Fig. 11.1)	3
within 4-15 μm)	T. binata	4-18 μm	4

[2]Valves flat, 10-30 um in diameter; girdle view rectangular or square with sharp corners; aerolar structure invisible under light microscope. Chains long, held by a single thin thread. Distance between adjacent cells usually less than pervalvar axis, as in T. mendiolana, or sometimes closer.

GROUP III	Leyanella arenaria	2-4 μm (Figs. 6.6, 10.5, 10.6)	1
(minute	Cyclotella? sp.	3-5 μm (Fig. 6.7)	2
species)	Minidiscus trioculata	2-5-4.5 μm (See Booth et al., 1982)	

Group I includes many species which tended to form blooms, although these showed no fixed pattern in the 1978-80 lagoon data. They occurred as follows:

August	1978	max. 12 000
February-March	1980	max. 18 000
July	1980	max. 3 000

At stations P1-P4 there were two to three Group I blooms a year, in early spring, mid-summer and autumn. Blooms in the open coastal waters did not produce concentrations greater than 5 000 cells per 10 ml.

From 1978-80, Group II centric diatoms (4-15 μm in diameter) were present in Esquimalt Lagoon all year except for January and February. Numbers were highest from May to October, with a summer maximum of 510 000 (in May 1979). The species composition must have varied, presumably between T. conferta, T. binata, Cyclotella sp. 2 and T. guillardii. T. pseudonana is a likely contributor, based on its occurrence in the area in general. Interestingly, T. conferta was almost always present in blooms of Group I species. T. guillardii is a brackish water species only (Hasle, 1978). In open waters, none of these species, either singly or in combination, has exceeded 7 000 (this at station P1, May 1977). T. conferta was the dominant Thalassiosira species at stations P1-P4.

As with the previous species, lagoon numbers for Group III were remarkably high (Fig. 3). Minidiscus trioculata may have been seen in the outer coastal area, but this has not been confirmed. The 3-5 μm Cyclotella? sp. was only found once, in Barkley Sound in July 1986 (maximum 20 000), when it was accompanied by desmids. Unfortunately, electron microscope preparations of this species were unsuccessful. L. arenaria was the most common minute centric diatom in the coastal waters and on line P (maximum 70 000 in May 1977 and 27 000 in August 1977 at station P1), and is the most likely candidate responsible for the 1978-80 lagoon numbers.

Other centric diatoms

The 1989 occurrence of other centric diatoms is summarized in Table 2. In 1978-80, L. minimus was the most commonly occurring species in Esquimalt Lagoon. It was present throughout the year except January and February (summer maximum 170 000 in May 1979;

winter maximum 360 in November 1979). L. danicus appeared from July to October (summer maximum 13 000). Detonula pumila, Eucampia zoodiacus and the Rhizosolenia species in the 1989 list (Table 2) tended to accompany blooms of Chaetoceros group * (Table 1), as is often the case in the outer coastal region. The maxima for these species were 6 700 Detonula (in May 1978) and 1 300 R. fragilissima (in August 1978), again exceptionally high counts.

Littoral species occurred quite often in the lagoon, especially during winter, presumably owing to storm action (Table 2).

In the coastal and offshore zones, station P4 marked a cutoff point for many of the familiar neritic diatoms, as mentioned previously. Beyond P4, there was in most cases a changeover to oceanic forms, such as Thalassiothrix, Rhizosolenia styliformis f. styliformis, R. alata f. alata, R. alata f. curvirostris, Chaetoceros atlanticum, C. boreale, Coscinodiscus centralis and C. marginatum.

PENNATE DIATOMS

Of the pennate diatoms listed in Table 3, the first 14 species are planktonic and neritic. The genus Nitzschia occurred commonly in coastal and offshore samples: N. cylindroformis in particular was frequently found, with summer maxima near the coast of 200 to 1 600, and 700 (in June 1987) at station P. This species has also been reported by Hasle and Booth (1984) from surface waters at oceanic stations. Twelve species of Hasle's (1965) Pseudonitzschia group (N. delicatissima and N. seriata complexes--some of which are listed in Table 3) were also seen frequently in our open coastal samples. Except for N. delicatissima itself, which was present all year, the Pseudonitzschias only tended to bloom once a year in July or August. They were usually accompanied by other planktonic Nitzschia spp., in particular, N. subcurvata, N. closterium, N. longissima, N. closterium v. striatula, N. granii v. curvata (Hasle's Nitzschiella group), and N. americana (Lanceolatae group; Hasle, 1964).[3]

There were only two major blooms of the N. seriata complex in Esquimalt Lagoon, 5 500 and 3 000 cells/10ml in April and July 1978 respectively. These appeared rather suddenly and in large numbers, suggesting that they may have represented intrusions from outside the lagoon. In the former case the bloom increased over a period of 15 days to 55 000/10 ml, a concentration five times the maximum seen in the open coastal waters. However, coastal blooms did not always enter the lagoon: a large bloom along the coast in August 1989 gave no evidence of its presence in the 1989 lagoon samples.

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[3]All these species did not necessarily coexist in the same water bodies but were often found together where different water bodies met (Forbes, in prep.).

The most frequently occurring planktonic pennate in the lagoon was N. closterium, whose numbers did not vary greatly throughout the year:

	Winter maximum	Summer maximum
1978	1100	1400
1979	140	560
1980	160	370

The remaining species in Table 3 are the lagoon's resident littoral, brackish and freshwater species.

DINOFLAGELLATES

Many of the coastal and neritic dinoflagellates of the outer B.C. coastal region flourish in Esquimalt Lagoon on a regular basis (Tables 4 and 5). There was no regular pattern of species succession from year to year: more than half of the reported species were present year-round in 1978-80, although all species peaked in abundance between May and October. Some species reached far greater (10-100X) concentrations in the lagoon than outside, for example:

photosynthetic

Aureodinium pigmentosum (Fig. 8.4)	120 000	Aug '78
Gymnodinium simplex (Fig. 8.2)	91 000	Aug '80
Katodinium rotundatum (Fig. 8.23)	62 000	May '80
Gymnodinium sanguineum	31 000	Oct '78
Scrippsiella trochoidea	3 100	Sep '79
Gymnodinium sp. 176 (Fig. 8.10)	1 313	Sep '89
Gyrodinium uncatenatum	170	Jun '80

heterotrophic

Glenodinium inaequale (Fig. 7.23)	7122	Apr '90
Gyrodinium cf. glaucum (Fig. 7.11)	6000	Aug '78
Glenodinium pilula (Fig. 7.25)	2200	Jul '78
Gyrodinium fusiforme (Fig. 7.15)	1900	Oct '79
Protoperidinium subinerme	1444	Apr '89
Peridiniopsis asymmetrica	850	Jun '79

Others reached very high concentrations but not much higher than sometimes seen elsewhere, for example:

1. Gonyaulax catenella (9 300 in August 1978), which forms red tides in Barkley Sound and other west coast inlets (Quayle, 1969);

2. Prorocentrum minimum (3 300 in October 1979), Heterocapsa triquetra (1 650 in October 1989), and Gonyaulax verior (940 in September 1980) which, along with Gymnodinium vitiligo, Gonyaulax tamarensis v. excavata and Scrippsiella trochoidea, form summer red tides in English Bay (near Vancouver, B.C.; unpublished UBC data).

Others did not fare as well in the lagoon as outside. The net result, however, was an exceptionally heavy population of dinoflagellates, including some very large cells (e.g., G. sanguineum). Heterotrophs in general appeared in the lagoon earlier in the year than did phototrophs.

Some new observations were made about several species:

1. We found it difficult at times to distinguish K. rotundatum (Fig. 8.23) from G. inaequale (Fig. 7.23).

2. Just as Prorocentrum balticum (Fig. 8.34) was not seen in the lagoon, P. minimum (Fig. 8.35) has not been seen on line P, where P. balticum is a dominant species.

3. Scrippsiella trochoidea has two forms. Both have been cultured. The inshore form is the one illustrated in Schiller's (1933) Figure 134 a-b, while the more widespread and familiar form is the one in his Figure 134 c-g. Only the latter was seen on line P, but both were observed in the lagoon.

4. If Gyrodinium cf. glaucum (Fig. 7.11) is in fact the species glaucum, then its size range is much wider than that given in the literature. An unbroken gradation of sizes has been seen here from 10-33 μm, as well as far lower numbers of cells from 33-46 μm. A spindle-shaped casing, 20 μm long, is quite common in these waters and appears to be a kind of cyst wall (Fig. 7.11a).

5. A larger, 30 μm "spindle" seen in the 1978-80 lagoon samples appears to be a similar type of casing for Pronoctiluca (Fig. 7.30).

6. Gyrodinium sp E (Fig. 7.12) is a coastal species, and is phagotrophic. It ingests cells in the region of its girdle and, like Gyrodinium spirale and G. fusiforme, was seen ingesting enormous cells for its size.

7. "Gonyaulax" rugosum (Fig. 8.15) is not a true Gonyaulax, but has been identified by F.J.R. Taylor (UBC) as a gymnodinoid type of most unusual character.

OTHER TAXA

Tables 6 and 7 show the remaining taxa recorded from Esquimalt Lagoon in 1989 and 1978-80, and their seasonal ranges and maximum abundances where, as before, numbers of that order of magnitude were recorded for several days. The 1989 sampling programme was not adequate for the purpose of showing seasonal trends, so this had to be provided by the 1978-80 data, while supplementary data from line P provided the most likely species names for some genera (Table 8).

As in the case of dinoflagellates, heterotrophic flagellates made an earlier start to the year than photosynthetic forms, and not surprisingly, ciliate blooms accompanied the blooms of small flagellates. The Oligotrichs and Choreotrichs (which include tintinnids) were seen feeding quite unselectively on any flagellates under 10 μm.

The only resident lagoon phytoflagellates (other than dinoflagellates) appeared to be:

Platymonas spp. (Fig. 9.23)
Nephroselmis longifilis? (Fig. 9.24)
Eutreptiella sp. 2
Eutreptia sp.
Chrysochromulina sp. 7 (Fig. 9.3) = Buchanan's sp. 1, also seen in English Bay
Unidentified sp. 19 (Fig. 9.41) 1978-80

Various colonial Chlorophyceae, Cyanophyceae (e.g., Merismopedia), and desmids, including Scenedesmus quadricauda and S. acuminatus, were also present, indicating freshwater input.

As most Prasinophycean species in their motile state and Haptophycean species in their naked state need confirmation by means of TEM of shadowcast body scales, hairs, etc., the unconfirmed species in Tables 6 and 7 are queried. Positive identifications of many of the unqueried species were made by Mrs. B.C. Booth and Dr. J.C. Green. Positively identified nanoflagellates are underrepresented in our lagoon lists when we compare these to the species lists of Smith (1991), obtained by TEM shadowcasting of raw water samples from Saanich Inlet.

A comparison between nearshore and offshore line P stations (Table 8) shows the extent to which non-diatom, non-dinoflagellate, coastal species are distributed outwards toward the open ocean station P. Unlike the neritic diatoms, they gave no clear delineation at station P4 between coastal and oceanic species. Although some coastal species were not found beyond P4 (e.g., Apedinella spinifera, Bipedinomonas pyriformis?), the majority of species were found at both the coastal and offshore stations. Table 9 includes several of the neritic and oceanic groups and species which were absent from the lagoon.

CONCLUSION

While it is clear that the phytoplankton composition of Esquimalt Lagoon varies from year to year, it does so within quite well defined limits. Some patterns are repeated each year and others every few years. The overall finding of this study is that the lagoon is highly productive, with respect to both biomass and species diversity.

The species composition ranges from freshwater to oceanic forms. It seems remarkable that such a wide diversity of species normally found in open waters occur in Esquimalt Lagoon. The lagoon as a whole must be sufficiently well flushed with high salinity water to permit the healthy growth of a variety of sensitive offshore species (e.g., Pterosperma spp.) in addition to its resident brackish water population.

In addition, there are species not mentioned in this report which have been included in the accompanying illustrations. These species have been observed in coastal and offshore waters off Esquimalt Lagoon, and are intriguing taxonomically, or may be toxic to fish. Additional drawings of lagoon species are held at the RRMC Chemistry lab, and further species lists and drawings are included with IOS cruise data from 1980 to 1989 (Forbes & Waters, in preparation). Authorities to species names and references to species descriptions are omitted from this report but are held at the RRMC Chemistry lab and at IOS Ocean Ecology.

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TABLE 1. Summary of Chaetoceros species identified from Esquimalt Lagoon. Group I, present in the lagoon, 1989; Group II, additional species present from 1978-80; Group III, species sometimes quite abundant in the coastal waters but not seen in the lagoon in 1989. + present, but <1 per 10 mL; * the usual most abundant spp. forming blooms in the lagoon, 1978-80; o species not found in the open coastal waters to date; ♦ the most common species in the open coastal waters and stations P1-P4, apparently neritic.

I		MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT
C. debile	*♦				3000	11			
sociale	*♦		1040		1000				
laciniosum	*♦	4000	700		14000				
compressum	*♦				20000	21			
constrictum	*♦				1500	13		4	
radicans	*♦	10000	14140		2000				
simile (single form)						232			
septentrionale	♦	500	436		1000				
lorenzianum	♦				1500				
teres								2	
simplex					10				
Gii (simplex v.calcitrans?) (Fig. 4.9)					20				
filiforme (Fig. 5.9)	♦		58						
perpusillum	♦					7140		14130	
breve (as in Cupp)			45						
new sp. D (Fig. 4.4)	♦				200				
new sp. F (Fig. 4.6)	♦					2010		5	
new sp. Gi (Fig. 4.8)	♦	20		150	10				
new sp. H (Fig. 5.1)					10000	497		2290	
new sp. M (Fig. 5.5)	♦				60	6			
new sp. J (Fig. 5.2)	o					28570		2780	
new sp. K (Fig. 5.3) (Buchanan's sp. I)	o					+			
new sp. L (Fig. 5.4)	o					3120		285	

II C. didymum *♦ C. decipiens ♦ C. difficile C. lauderi
diadema *♦ decipiens f. singularis ♦ pseudocrinitum ♦ danicum
crucifer *♦ curvisetum vanheurckii ♦ pelagicum ♦ (Fig. 4.7)
simile (chain form) ♦

III C. convolutum ♦ C. affine ♦ C. tortissimum C. subtile
cinctum * vixvisibilis new spp. B♦, E, N (Figs. 4.2, 4.5, 5.6)

TABLE 2. Summary of other centric diatom species found in Esquimalt Lagoon, 1989. ♦ Littoral species.

	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT
Coscinodiscus oculus-iridis					1			
C. apiculatus	3							
C. asteromphalus			3					
C. radiatus			2					
Asteromphalus sp. (Fig. 6.3)					2			
Detonula pumila				10				
Ditylum brightwelli				+				
Cerataulina pelagica								2
Leptocylindrus danicus				16				
L. minimus					40		990	
Rhizosolenia setigera				+				
R. stolterfothii				+				
R. fragilissima			4				3	
R. fragilissima var.1 (Fig. 6.1)					9			
R. delicatula				13				
Unidentified cylinders (Fig. 6.2)				10				
Eucampia zoodiacus		7			11	15		
Stephanopyxis nipponica	8	4						
Biddulphia aurita ♦						2		
Lithodesmium undulatum ♦		1						
Melosira nummuloides ♦						48		
M. juergensenii ♦						23		
M. hyperborea ♦						3		
Paralia sulcata ♦						5		

TABLE 3. Summary of pennate diatoms in Esquimalt Lagoon, 1989. ♦ member of *Pseudonitzschia* subgroup, o member of *Nitzschiella* subgroup, * freshwater.

		MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT
Nitzchia closterium	o	<10	16	20	100	134	550	6	2
N. v. striatula	o		15						
N. longissima	o	<10	33	10	50	463		90	
N. bicapitata	o						88		
N. norwegica	o		14						
N. subcurvata	o				<5				
N. delicatissima	♦		17		100		3	8	
N. lineola	♦		+						
N. seriata	♦		30						
N. seriata f. obtusa	♦				10				
N. pungens	♦		11						
N. cylindroformis			122	10000	20		588		
N. americana					100	16	2		
Cylindrotheca fusiformis			5			8	9	3	
Thalassionema nitzschioides		<10	47	10					
Nitzschia bilobata			4						
N. droebakensis	o			5	5				
N. impressa	*				5				
Synedra spp.		<10	7				9	4	2
Fragilaria spp.			6		10				
Caloneis Stauroneis Diploneis } ? spp				5	5				
Cocconeis scutellum v. parva					400 (empty)		5060	15	
Asterionella formosa	*		14				4		
Licmophora lyngbei			7		10		25	2	
Licmophora sp. 1 (Fig. 6.10)					200		18		
Navicula cf. arenaria[1]							202		
Navicula sp. 1 (Fig. 11.2)					100		97		
Navicula sp. 2 (Fig. 11.4)			37			95	812	7	

TABLE 3 (Cont.)

		MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT
Stauroneis? (Fig. 11.3)							4140	171	11
Amphora sp.			8		5		163		42
Amphiprora paludosa							92	3	
Amphiprora spp.			6		10				
Achnanthes longipes					5			2	
Striatella unipunctata							91		
Gyrosigma strigilis					5				
Gyrosigma sp. (360μm; cf. Shim[2])			52				6	2	
Pleurosigma fasciola			+						
Pleurosigma cf. elongatum 200μm			8			7			
Tabellaria fenestrata	*	<10							
Misc. pennates 10-18μm			792		300				

[1] 63-100 μm x 8.4-10 μm; 10 striae in 10 μm; lanceolate
[2] Shim (1977) p.181

TABLE 4. Occurrence of photosynthetic dinoflagellates in Esquimalt Lagoon, 1989. ⊕ Also at P1-P3, o also at P5-P, ■ often a dominant species at station P.

		MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT
Gymnodinium cf. aureolum (Fig. 8.8)	⊕■					504	2000		
Gymnodinium sp. 94 (Fig. 8.9)	⊕o	10	2						
G. gracilentum (Fig. 8.4)	⊕■	20	28	50		7		18	
G. sanguineum	⊕						208	7204	7150[1]
G. simplex (Fig. 8.2)	⊕■						240		
G. vitiligo (Fig. 8.1)	⊕■		10						
G. sp. 176 (Fig. 8.10)	⊕■							1313	72
G. cf. flavum (Fig. 8.3; as in Wailes, 1939)	⊕							3	
Katodinium rotundatum 9-14 µm (Fig. 8.23)	⊕o			7000	10	66	21	8	
"Gonyaulax" rugosum (Fig. 8.15)	⊕o					15	9	10	
Cochlodinium citron (Fig. 8.17)	⊕							6	
Amphidinium carterae (Fig. 8.20)							67	2	
A. klebsii (Fig. 8.21; as in Lebour, 1925)							2		
Aureodinium pigmentosum (Fig. 8.14)	⊕■				1000	782		15	
Prorocentrum gracile	⊕							3	
P. micans	⊕							1	
P. minimum (Fig. 8.35)						8	8	42	28
P. aporum? (Fig. 8.28)	⊕o	+				+	+	+	
Dinophysis acuminata	⊕	5	364	300	200	15	21	396	695
D. acuta	⊕				10		3	2	
D. ovum	⊕					3	16	58	
D. parva? (Fig. 8.27)	⊕						6		
D. schröderi? (Fig. 8.26)	⊕					1			
Protogonyaulax catenella	⊕o							5	
G. spinifera	⊕o				30	4			
Protoceratium? sp. 60-70µm	⊕		12						

[1]Cells rounding off

TABLE 4 (Cont.)

		MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT
Alexandrium (Goniodoma) ostenfeldii (Fig. 8.25)	⊕o				5				
Scrippsiella trochoidea									
as in Schiller, 1933,a&b					200	21	55	2	
as in Schiller, 1933, c-g	⊕o				50	9	18	3	
S. sweenyae	⊕o				+				
S. cf. Peridinium hyalinum	⊕							4	
S. sp. U 9.4-14μm (Fig. 8.24)	⊕o						2		
Heterocapsa triquetra	⊕o		3		20	214	3	144	1652
Ceratium fusus	⊕o								1

TABLE 5. Occurrence of heterotrophic dinoflagellates in Esquimalt Lagoon, 1989. ⊕ Also at P1-3, o also at P5-P, ■ often a dominant species at station P.

		MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT
Gyrodinium spirale + G. brittanicum	⊕o	5	4		10	7	3		
G. fulvum (as in Wailes, 1939) 30μm	⊕o		4		5			6	
G. fusiforme (Fig. 7.15)	⊕o	10	208	5	10		220	5	
G. cf. lachryma (Fig. 7.13)	⊕o					7		2	
G. cf. glaucum (Fig. 7.11) (Buchanan's sp.1)	⊕■		30	5	400	72	58	135	
G. pinque			+				+		
G. lebourae? (Fig. 7.14)			306			16		7	
Gyrodinium? sp. E (Fig. 7.12)	⊕o						12		
Gymnodinium bifurcatum									1
G. sp. O (Fig. 7.7)	⊕o	5		5					
G. sp. V (Fig. 7.3)	⊕o		385	10	100		55	2	
G. sp. H (Fig. 7.8)	⊕	10			2000	912	424	26	
G. sp. C (Fig. 7.1)	⊕■			10		12		6	
G. sp. W (Fig. 7.2)	⊕■			5	50	26	11	10	
G. sp. G (Fig. 7.9)	⊕	5		50		3		15	
G. stellatum (Fig. 7.10)	⊕o							2	
G. lazulum	⊕					3			
Misc. Gymnodinium spp. (incl. Fig. 7.4)		10	28			90	10		
Amphidinium longum (Fig. 7.20)	⊕o						3	6	
A. sphenoides (Fig. 7.21)	⊕o							3	
A. sp. Y (Fig. 7.18)	⊕o		103			10	63	148	
Nematodinium armatum	⊕o					41	45		
Polykrikos kofoidii	⊕o		5	5	10	49	18	4	
Noctiluca scintillans	⊕o						4	1	
Glenodinium inaequale (Fig. 7.23)		1000	7122	200	10	1024		12	
"Glenodinium" sp. M (Fig. 7.24)	⊕	10	591	2000	100	5		2	
G.pilula as in Buchanan (Fig. 7.25)	⊕		460				31	107	4
Peridiniaceae sp. S (Fig. 7.26)	⊕	30		5	10	4	16		

TABLE 5 (Cont.)

		MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT
Plain Peridiniaceae/Glenodinium types[1] 10-30μm		30	312			7	6		
30-50μm		10	124			10	18	3	
Peridinium obtusum	⊕	10	1444	5	20	56	39	4	
P. depressum	⊕○		6		10	7	2		
P. pellucidum	⊕○						3	3	
P. claudicans	⊕					21		1	
P. divergens	⊕○						18		
P. divaricatum		5							
Diplopsalis lenticula	⊕	5		10					
Peridiniopsis asymmetrica	⊕		117	5		266	155	20	3
Zygabikodinium lenticulatum	⊕	+							

[1] Refers to species without spines, lists, horns, etc., and may even be without plates. Typical shapes are those of Scrippsiella, Peridinium hyalinum, P. nudum, Glenodinium danicum.

TABLE 6. Occurrence of other phototrophs in Esquimalt Lagoon, 1989 and 1978-80.

	1989								1978-80		
	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	MAX.	PEAK MO.	OCCUR
Raphidophyta (Chloromonadophyta)											
Raphidophyte 1 (Fig. 9.36)					7						
Raphidophyte 2 (Fig. 9.37 & 37a)					9		5				
Heterosigma akashiwo (Fig. 9.39)									not counted		+
Chrysophyta											
Apedinella spinifera (Fig. 9.20)	1000	34			3248	456	1767		13000	Sep	All Year
Pseudopedinella pyriformis (Fig. 9.21)		1810	3000	200	23100	503	10		16000	Jul	All Year
Pedinellacean sp. 239 (Fig. 9.19)					75	134	303				
Pedinellacean sp. 223 (Fig. 9.18 & 18a)		146									
Dictyocha speculum			10								
Dinobryon suecicum				50	31	272	236		1500	Nov	Nov-Mar
D. sertularia							241				
D. divergens[1]					10			12			
Ochromonas spp. 1.5-3μm		125			62				23000	Sep	Aug-Sep
Meringosphaera mediterranea					15						
Haptophyta											
Imantonia rotunda &/or Dicrateria inornata, up to 3.5μm (Fig. 9.12)		7323							81000	Sep	Apr-Sep
Phaeocystis sp. 224 (Figs. 9.11, 11.5, 12.1, 12.2)		75									
P. pouchetii colonies (cells shown in Fig. 9.13 & 13a)									100	Mar	Mar-Nov

[1] See Plate I Fig. 5 in Taylor & Waters (1982).

TABLE 6 (Cont.)

	1989								1978-80		
	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	MAX.	PEAK MO.	OCCUR
Corymbellus sp. (Figs. 9.13, 12.6)		8									
Chrysochromulina sp. 63 (Figs. 9.7, 12.3, 12.4)		10230				862	2427	2014	63000	Sep	All year
Chrysochromulina (saddle) 4-5.5µm (Fig. 9.1 & 1a)						86			120000	Oct	Apr-Oct
C. (saddle) 6-10µm (Fig. 9.9)						28	21		1300	Sep	Feb-Oct
C. (round) 3-6µm (Fig. 9.8)		1004		200	11	304	1020	3418	110000	Sep	All Year
C. (round) 6-9µm (incl. Fig. 9.6)		36				52					
C. ericina							6375		2000	Jul	Apr-Dec
C. parva?									450000	May	May-Sep
C. parkeae? (Fig. 9.2)									1200	Oct	May-Dec
C. polylepis (Fig. 9.5)									62000	Oct	Aug-Oct
C. sp. 7 (Fig. 9.3 & 9.3a)									30000	Sep	Sep-Feb
Prymnesium 16-25µm (Fig. 9.15)									23000	Sep	Aug-Sep
Chlorophyta											
Colonial Chlorophycean					34 colonies						
Prasinophyta											
Pterosperma & Pachysphaera spp. (Fig. 9.32)						24			12000	Nov	Oct-Nov
Cymbomonas sp. (Fig. 9.34)					12				590	Jul	Jul-Oct
Pyramimonas sp. 3-5µm (Fig. 9.23)		1233	500		3625		285		9200	Apr	Mar-Jul
P. spp. 5-8.5µm (Fig. 9.23)	1000	487		1000	7218	511	552		190000	May	All Year

TABLE 6 (Cont.)

	1989								1978-80		
	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	MAX.	PEAK MO.	OCCUR
Nephroselmis? sp. (Fig. 9.25)		216			20	206					
N. longifilis? (Fig. 9.24)		11			11	4			14000	Sep	Apr-Sep
Bipedinomonas or Nephroselmis semiglobata &/or pyriformis? (Fig. 9.27)		43			54	17	12				
Bipedinomonas? sp. (Fig. 9.28)		6560	20		1368	135	52	6			
Platymonas sp. 10.5-14.2µm (Fig. 9.23)				200	1170	2840	47		5000	Jul	Jul-Aug
Micromonas pusilla (Fig. 9.31)		1200									
Euglenophyta											
Eutreptiella marina			30	30	16	12	13	2	27000	Aug	All Year
E. sp. 18-28 x 3.5-5µm (Fig. 9.42)				1000	1355	8	12		200	Sep	Sep
E. sp. 2 100 x 7µm									12000	Nov	Nov
Eutreptia sp.									520	May	May
Cryptophyta											
Cryptomonas (red-tailed) 18-25µm		8084					118	2			
Cryptomonas (red-tailed) 9-17µm (Fig. 9.43)	4000	3566	5000	5000	21420	2738	444		290000	Sep	All Year
Plagioselmis (brown) 6-9µm (Fig. 9.43)	6000		5000	5000	16160	1475	572				
Hemiselmis cyclopea	20000	69440	10000	2000	14050	680	1627	75	120000	Aug	All Year
H. rufescens (incl. in Fig. 9.44)		812									
Chroomonas (yellow) 10-16µm				50		21	11				

TABLE 6 (Cont.)

	1989								1978-80		
	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	MAX	PEAK MO	OCCUR
Cyanobacteria											
Merismopedia spp.		375				3002	1925				
Synechococcus spp.		242000	100000								
Protozoa											
Mesodinium rubrum	100	312	50	20	137	76			1200	Sep	All year

TABLE 7. Occurrence of other heterotrophs in Esquimalt Lagoon, 1989 and 1978-80.

	1989								1978-80		
	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	MAX.	PEAK MO.	OCCUR
Paraphysomonas sp. (Fig. 6.27)	3700	4000	3000								
Calcycomonas gracilis											
Chilomonas sp.	20					14					
Salpingoeca natans	600	3000	500	50					21000	Mar	All Year
Pleurasiga sp.	300	1000	100								
Phacomonas pelagica (Fig. 6.15)	30	1814	1000				84		18000	Sep	Apr-Sep
Bodonid 1 (Fig. 6.16)	1000		1000								
Bodonid 2 (Fig. 6.17)		1000									
Ebria tripartita (Fig. 6.18)	20	14		10	161	112	2		1300	Jun	All Year
Flagellate (viii) (Fig. 6.23)	1000	204		500	345	21	1142	113	9600	Apr	All Year
Flagellate sp. 2 (Fig. 6.30)			20								
Flagellate (ix) (Fig. 6.22)	20										
Flagellate sp. 4 (Fig. 6.26)								264			
Flagellate (xvi) (Fig. 6.24)					2800						
Rhynchomonas pusillus (Fig. 6.14)		45									
Petalomonas sp. (Fig. 6.19)		11									
Misc. 0.5-3μm	20000	50000	50000	30000	20000	10000	30000	20000	20000-180000		All Year
Fungi				40							
Spiny cysts 30-70μm					97	42					
Cysts and eggs					22	43	4				

TABLE 7 (Cont.)

LARGE OR DOMINANT CILIATES ONLY

	1989								1978-80		
	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	MAX.	PEAK MO.	OCCUR
Holotrichida											
Uronema sp.		20		100					980	Jun	All Year
Unidentified Holotrich		5			97	68					
Oligotrichida											
Strombidia 13-25μm		22	10	5	11	27	5				
26-45μm		93	3	5	34	20		1			
S. conicum		31			3		2		1700	May	All Year
S. conicoides					135						
S. reticulatum				1	4						
S. cornucopiae					2	3					
Tontonia spp.		2			3	3	2				
Choreotrichida excl. Tintinnina											
Lohmanniella spp.	5	65			9		2	1			
Strobilidium spp.	3			20							
Leegaardiella spp.				4	11	12	3				
Tintinnina											
Tintinnopsis minuta			100		186	37					
T. cf. lobiancoi 109μm					11				500	July	All Year
T. cf. laevigata					124	4	2				
Helicostomella kiliensis	2	4	5		806	1					
Eutintinnus pectinis		2	5								
Parundella translucens				3	5						

TABLE 8. Occurrence of most abundant other phototrophs on line P, 1973-77. ≠ greatest abundance for that species.

	P1-P3												P5-P											
	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D
Raphidophyta																								
Raphidophyte 1 (Fig. 9.36)						=	=	=												=				
Raphidophyte 2 (Fig. 9.37 & 37a)			=					≠	=	=				=	=	=	=	=	=	=	≠		=	
Heterosigma akashiwo (Fig. 9.39)					≠				=	=	=	≠					≠	=			=	=	=	
Chrysophyta																								
Pseudorocella? sp. (Figs. 9.45, 12.7)																				=				
Apedinella spinifera (Fig. 9.20)			=	=	=				=	=														
Pseudopedinella pyriformis (Fig. 9.21)		=							=						=	=								
Pedinellacean sp.239 (Fig. 9.19)					=			=	≠					=	=	=	=			=	≠		=	
Pedinellacean sp. 223 (Figs. 9.18, 11.6)								=									=	=	=	=			≠	=
Ochromonas sp. 190 (Fig. 9.22)			=	=	=			=						≠	≠	≠	≠				≠	≠		
Dictyocha speculum			=	=	=					=	=	=			=					=				
Dinobryon suecicum			=											=										
Xanthophyta																								
Phacomonas pelagica (Fig. 6.15)		=	=		=	=	=	=		=							=							
Haptophyta																								
Chrysidalis sp.					=															=				
Imantonia rotunda (Fig. 9.12)		=	=	=	≠	≠	≠	≠	≠	≠	≠	=		=	≠	≠	≠	≠	≠	≠	≠	≠	≠	=
Dicrateria gilva																				=				

TABLE 8 (Cont.)

≠ greatest abundance for that species

	P1-P3												P5-P											
	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D
Phaeocystis sp. 224 (Figs. 9.11, 11.5, 12.1, 12.2)			=	=	=			=		=				=	≠	=	≠			≠	=	=		
P. pouchetii (Fig. 9.10)			=	=	≠					=		=	=	=	=	=	=	=			=	≠	=	=
Prymnesium sp. 11-17 μm (Fig. 9.14)								=	=															
Corymbellus aureus									=												=			
Corymbellus sp. (Figs. 9.13, 12.6)		=		=	≠			=				=			=	=	=							
Gephyrocapsa oceanica																								
Emiliana huxleyi (Fig. 9.16)	=	=	=	=	=	≠	=	=	≠	=	=	≠	=	=	=	=	=	≠	=	≠	=	≠	=	=
Coccolithus pelagicus		=	=	=	=			=	=	=				=	=	=	=			=	=	=		=
Cyclococcolithus leptoporus																				=				
Chrysochromulina sp. 63 (Figs. 9.7, 12.3, 12.4)			=	=	=	≠	≠	≠	≠	≠		≠					=	≠	≠	≠	≠	≠	≠	≠
C. cymbium+ephippium		=	=	=	=	=	=	=	≠	≠	=	=		=	≠	=	=	=	=	≠	≠	=	≠	=
C. minor + sp. 28 (Figs. 9.8, 12.5)		=	=	=	=	=		=		=		=			=	=	≠	=				=	=	=
C. herdlensis		=	=	=	=	=		=		=		=			=	=	≠	=				=	=	=
C. brevifilum					≠	=	=	≠	=	=		=					≠	≠	=	=	=			=
C. leadbeateri (Fig. 9.6)					≠				=	=		=					≠				=			=
C. ericina		=	=	=	=			=	=						=	=	≠	=	=	≠	=	=		
C. bergenensis		=	=	=	=			=	=						=	=	≠	=	=	≠	=	=		
C. mantoniac						=		=											=	=				
C. parkeae (Fig. 9.2)					=			=									=			=	=	=		
C. polylepis (Fig. 9.5)			=	=	=												=							

TABLE 8 (Cont.)

≠ greatest abundance for that species

	P1-P3												P5-P											
	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D
Prasinophyta																								
Pterosperma+Pachysphaera (Fig. 9.32)	=		=	=	=	=	=	=	=	=	=	=			=	=	=	=	=	=	=	=	=	
Halosphaera spp.			=					=	=	=					=	=	=	=	=	=	=	=		
Cymbomonas sp. (Fig. 9.34)			=						=															
Pyramimonas spp. 3-8.5µm (Fig. 9.23)		=	=	=	=			≠	=	=	=	=			=									
Nephroselmis gilva			=	=	=			=	=								=							
Bipedinomonas caeca			=												=									
B. pyriformis? (Fig. 9.27)		=	=	=	=			=																
Pseudoscourfieldia marina								=	=									=						
Micromonas pusilla (Fig. 9.31)	≠	=	=											=	=	=	≠					≠		
Cryptophyta																								
Cryptomonas minuta		=	=	≠	=	=	≠	≠	≠	≠	≠	≠			=	=	≠	≠	=	=	≠	≠	≠	≠
Plagioselmis 6-9µm (Fig. 9.43)					≠	≠	≠	≠	≠	≠	≠	≠					≠	≠	=	=	=	≠	≠	≠
Hemiselmis rufescens (Fig. 9.44)					=					=												=		
H.brunnescens+cyclopea					=	=		≠													=			
Protozoa																								
Mesodinium rubrum									=	=											=			
Miscellaneous																								
Flagellate (viii) (Fig. 6.23)			=			=		=		≠					=		=					≠		
Rhynchomonas pusillus (Fig. 6.14)		=		=	=												=							

TABLE 9. Some likely contributors to several Table 6 groupings based on confirmed frequency at P1.

		Means of confirmation
Chrysochromulina spp. (saddle) 6-10µm	C. ephippium	TEM shadowcasting of scales
	C. cymbium	& comparison of live cultures
(round) 3-6µm	C. minor	"
	C. sp. 28	"
(round) 6-9µm	C. leadbeateri (Fig. 9.6)	"
Pyramimonas spp. 5-8.5µm	P. obovata	"
	P. grossii	"
	P. orientalis	"
Cryptomonas spp. (red-tailed) 9-17µm	C. minuta v. minuta	LM comparison of live cultures
	C. minuta v. planktonica	"
	& generally smaller numbers of unidentified species	
Pterosperma and Pachysphaera spp. (The majority of Pachysphaera species found are unnamed, however.)	Pterosperma nationalis	LM phycoma[1]
	P. michaelsarsii	" 2
	P. marginatum	" 1
	P. moebii (Fig. 9.33a)	" 1
	P. polygonum type(s)	" 1,2
	P. cuboides	" 1
	P. vanhoeffeni	" 1
	Pachysphaera pelagica	" 3
	P. marshalliae	" 3

[1] Parke *et al.*, 1978
[2] Taylor & Waters, 1982
[3] Parke, 1966

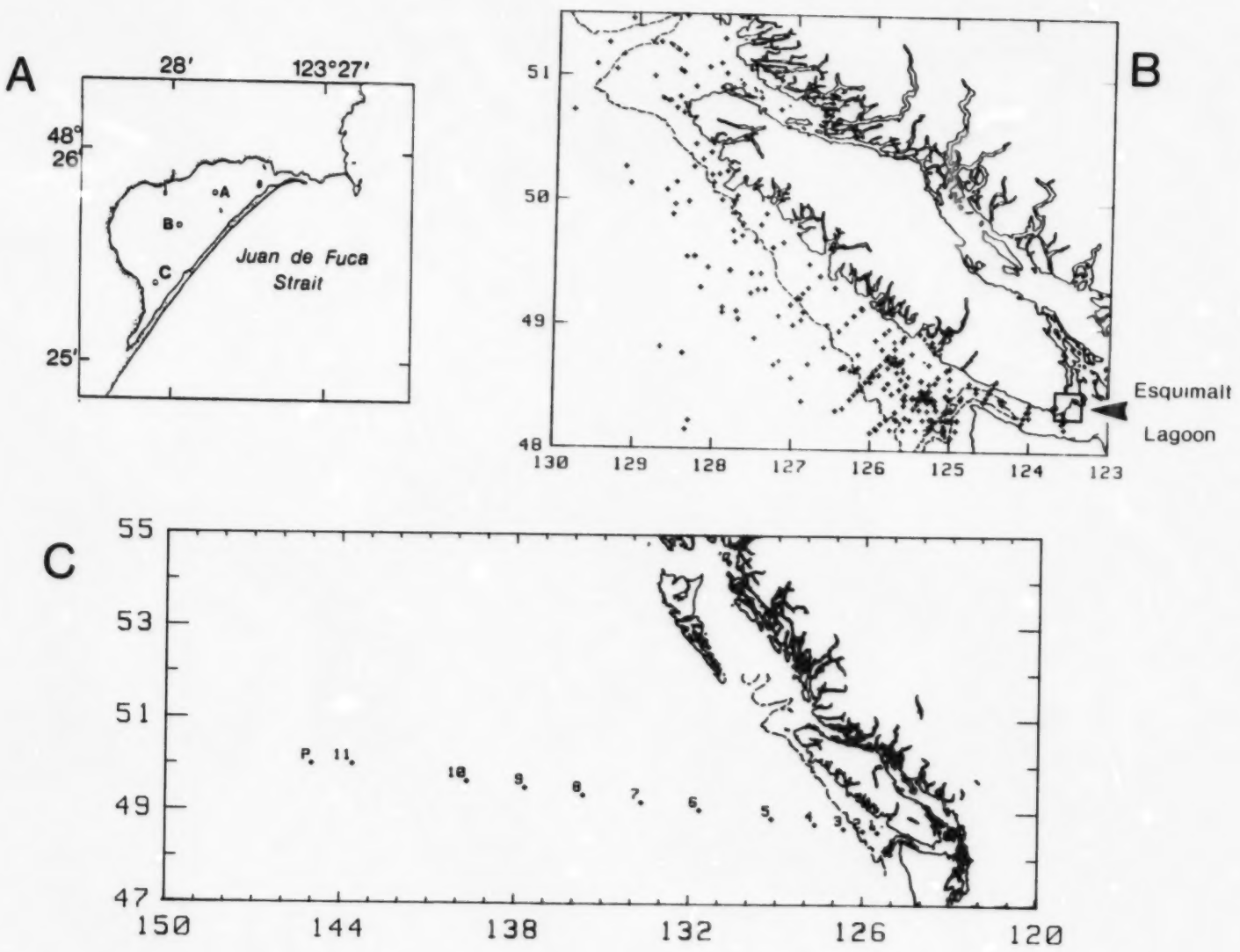

Figure 1. Locations of sampling stations. A. Esquimalt Lagoon B. IOS coastal stations C. Line P. Dashed line in B and C indicates the 200m depth contour.

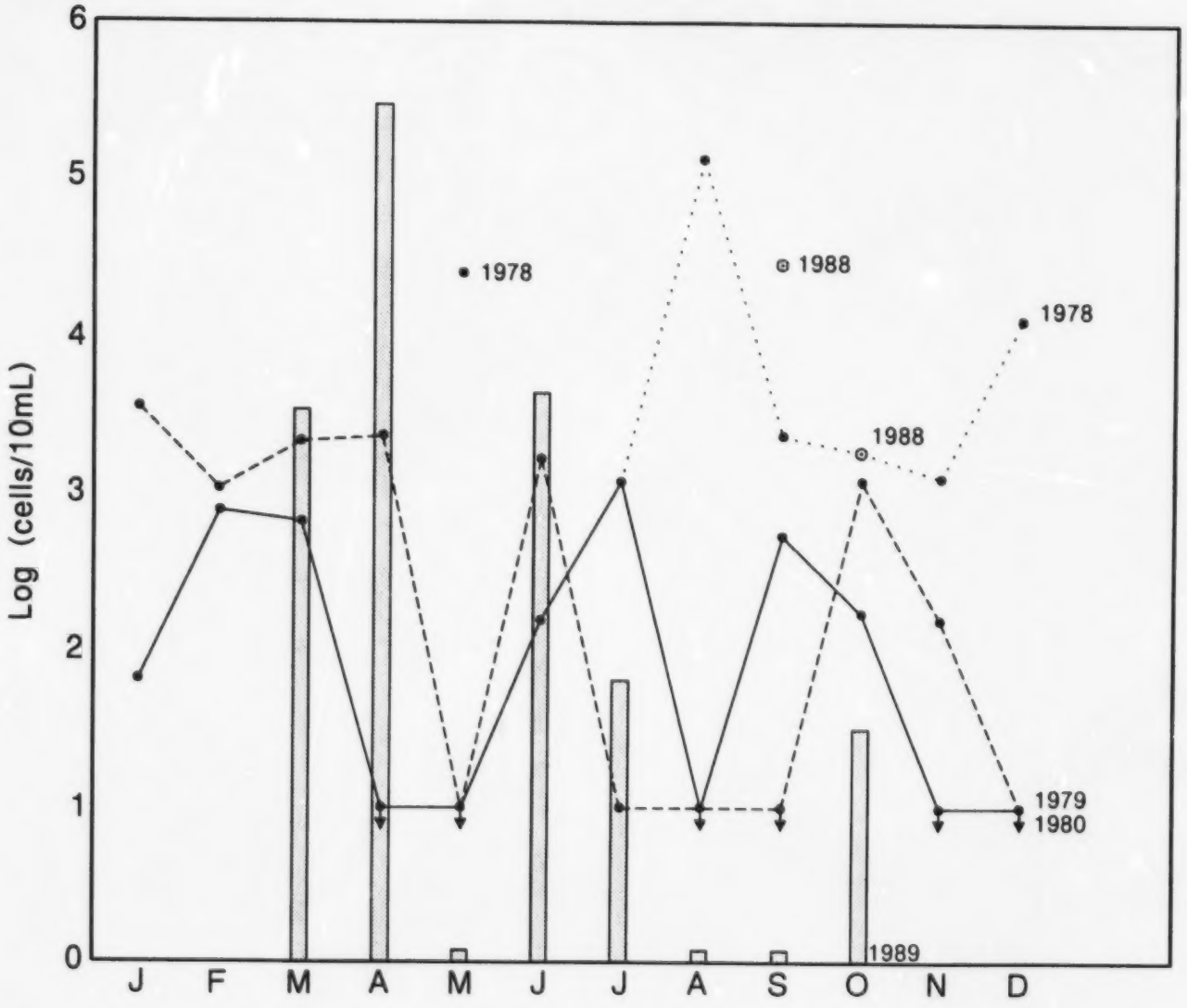

Figure 2. Abundance (cells/10mL) of *Skeletonema costatum* in Esquimalt Lagoon. •···• 1978, •---• 1979, •——• 1980, ⊙ 1988, bars 1989.

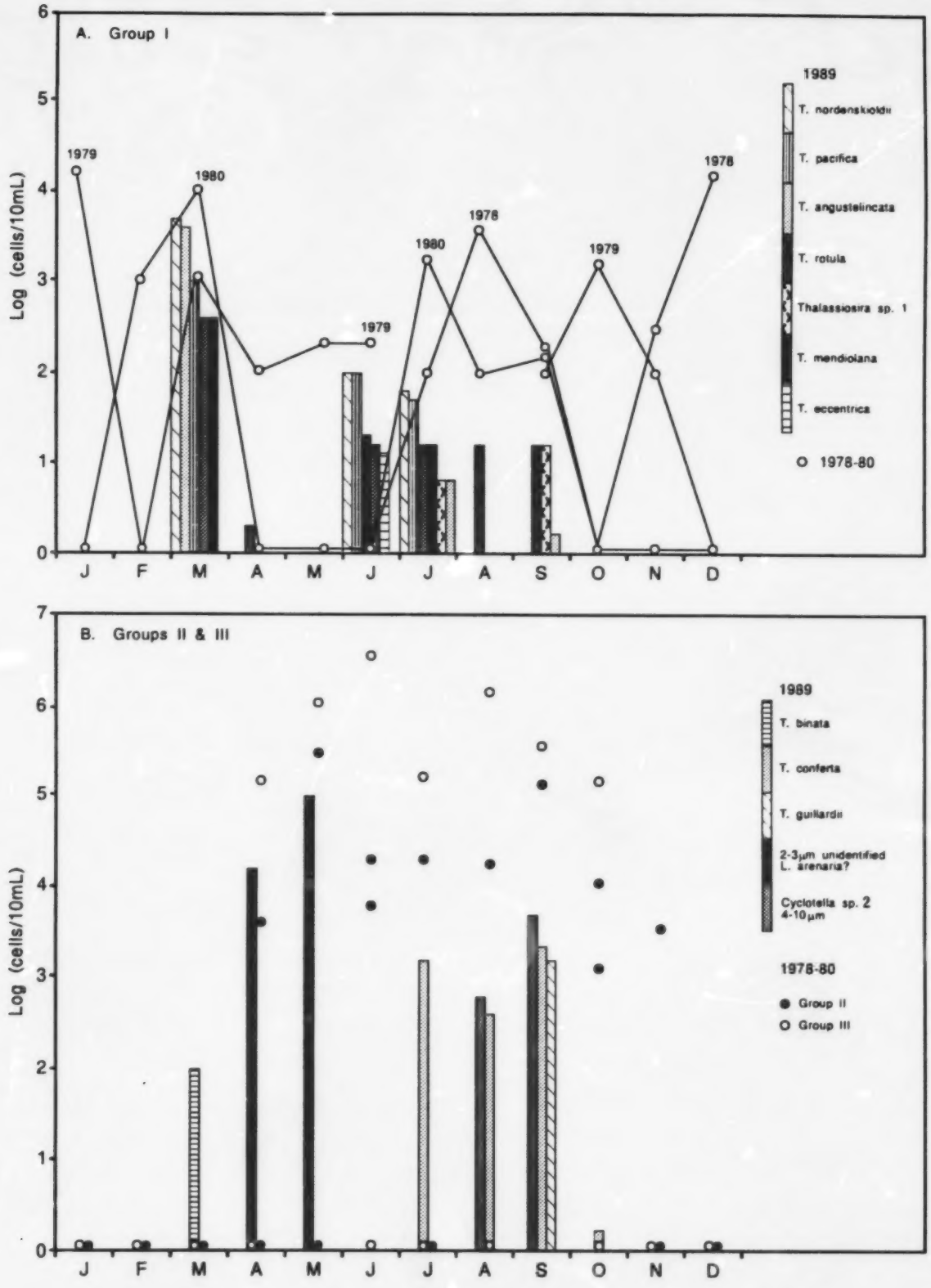

Figure 3. Occurrence of discoid centrics in Esquimalt Lagoon. Bars give abundance in cells/10mL for 1989; other data give monthly maxima for 1978-80. A. Group I B. Groups II and III.

Figure 4

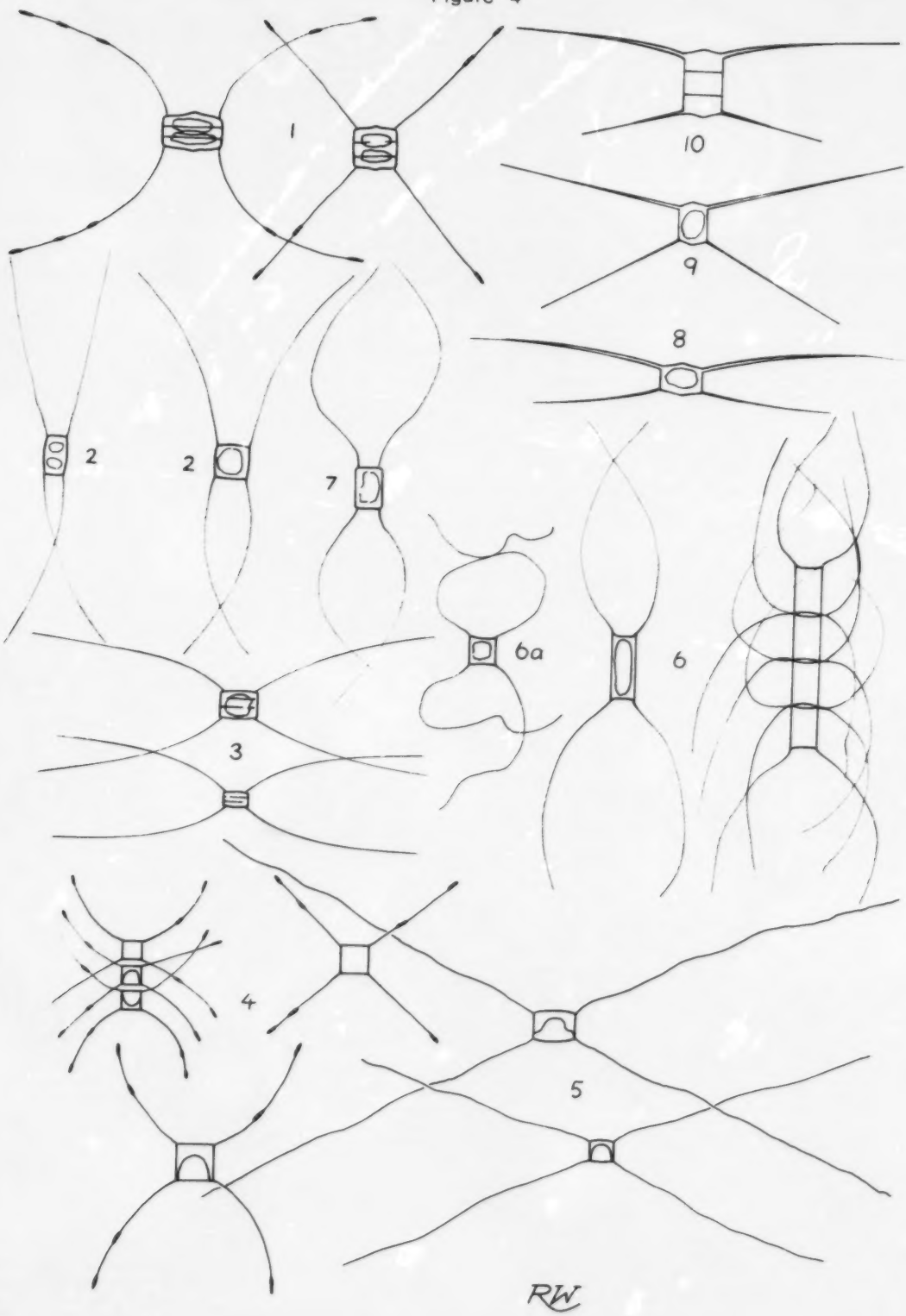

FIGURE 4. *Chaetoceros* spp. Unless stated otherwise, these and subsequent drawings are of cells preserved in Lugol's iodine, as seen under the inverted microscope during counting. Hence detail is limited and sometimes only the cell outline is shown. The cell contents often appear to merge into large clumps when fixed and do not then represent the live state. Scale in these and subsequent drawings is 1 cm = 10 μm.

4.1 *Chaetoceros* sp. A. Width 4-10.5 μm, length 4-8.5 μm; elliptical valve, convex, raised in centre; setae in one plane, curved or straight, arise in from edge of valve and appear to contain chloroplasts. Cells single, 1 chloroplast.

4.2 *Chaetoceros* sp. B. Width 3-5 μm, length 5-7 μm; elliptical valve, flat or slightly convex; setae curve into different planes (not in focus together), arise from edge of valve. Pairs of setae can differ in thickness from other pairs, throughout a population or in one cell. Cells single, 1(?) chloroplast.

4.3 *Chaetoceros* sp. C. Width 4-6.5 μm, length 2.5-6.5 μm; elliptical valve, slightly convex; setae in one plane, very thin, curved, arise in from edge of valve. Cells single, 1 chloroplast.

4.4 *Chaetoceros* sp. D (cf. *C. perpusillum* but most setae appear to contain chloroplasts). Width 3.5-7 μm, length 3.5-6.5 μm; elliptical valve, flat; setae curved or straight, arise from edge of valve and lie in one plane. Cells single or in chains of 2-3. 1 chloroplast.

4.5 *Chaetoceros* sp. E (cf. *C. muelleri*). Width 4-7.5 μm, length 4-6.5 μm; elliptical valve, slightly convex, slightly raised in centre; setae very long (to 67 μm), wavy, arise from edge of valve, lie in one plane. Cells single, 1 chloroplast.

4.6 *Chaetoceros* sp. F. Width 3.5-5.5 μm, length 7-10 μm; elliptical valve, slightly concave, edge of valve extended up to the setae; setae curve into different planes. Cells single or in short chains, 1 chloroplast.

4.6a *Chaetoceros* sp. F? as for F but very wavy setae and not *C. septentrionale*.

4.7 *Chaetoceros pelagicum*, single form? As for sp. F but valve is flat and setae arise in from edge of valve.

4.8 *Chaetoceros* sp. Gi. Width 5-7 μm, length 4-6 μm; elliptical valve with raised centre; setae arise from edge of valve and curve into different planes; setae initially thick, taper outwards, one pair usually thicker and longer than the other, though the thickness of the top pair is exaggerated here. Cells single, 1 chloroplast. Not *C. simile*, *C. gracile*[1], *C. simplex*, not in Hustedt. Sometimes confusable with *Chaetoceros* sp. B and *C. simile*? single form.

4.9 *Chaetoceros* sp. Gii. (*C. simplex v. calcitrans*?). Width 4-6 μm, length 7-10 μm; elliptical valve, convex and raised in centre; setae straight, arise from edge of valve and lie in one plane; one pair of setae is thicker than the other, and tapers. Cells single, 1 chloroplast.

4.10 *Chaetoceros simile?* single form. Width 4.5-14 μm, length 5-20 μm. Appears to be as described for *C. simile*, though many cells are squat, like sp. Gi, and too small for *C. simile* proper. 2 chloroplasts.

---

[1]Often reported from B.C. coastal waters, *C. gracile* was rarely found in any UBC or IOS samples, and confusion with one of these unnamed species may be a common occurrence. Cupp described it as "not common," which cannot be said of any of the similar-looking single-celled species described here.

Figure 5

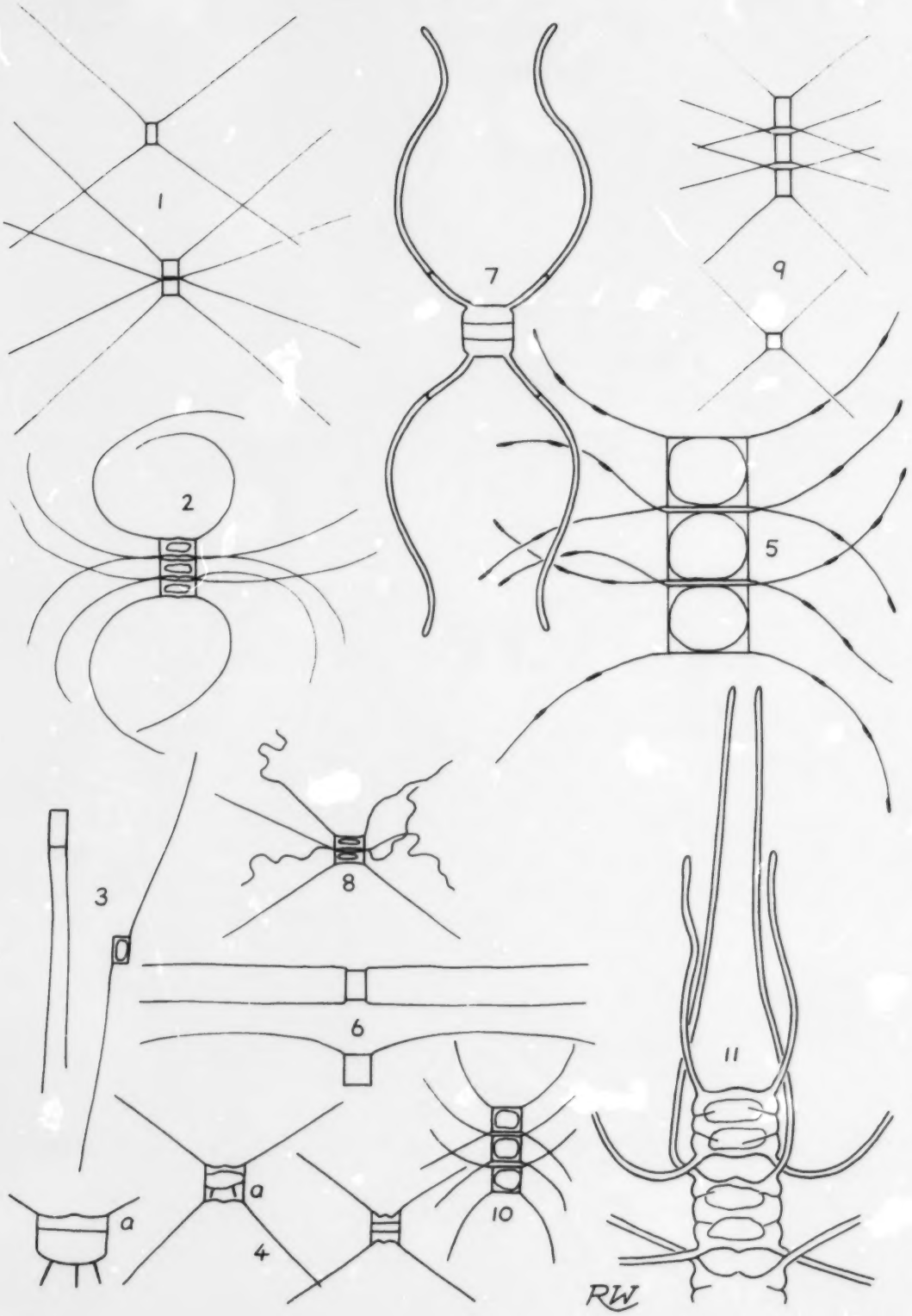

FIGURE 5. *Chaetoceros* spp.

5.1 *Chaetoceros* sp. H. Width 2-4 μm, length 4-8 μm; elliptical valve, flat; setae in one plane, long, very thin, straight but occasionally slightly curved, arise from edge of valve. Cells single, or in short chains with narrow aperture. 1 chloroplast.

5.2 *Chaetoceros* sp. J. Width 5-7 μm, length 2-3.5 um; elliptical valve, concave but raised in centre; setae thin, very curved, arise from edge of valve. Cells usually in short chains, aperture narrow. 1 chloroplast.

5.3 *Chaetoceros* sp. K. Width 3 μm, length 6 μm; elliptical valve, flat; setae very long, straight, in one plane, arise from edge of valve; often seen as illustrated (also in Buchanan, 1966), but sometimes in chains having the appearance of *C. subtile* but with far longer setae. 1 chloroplast.

5.4 *Chaetoceros* sp. L. Width 4-13 μm, length 4-10 μm; elliptical valve, concave but raised in centre; setae straight, in one plane, edge of valve extended up to the setae. Cells single or in short chains. 1 chloroplast. 4a: resting spore.

5.5 *Chaetoceros* sp. M. Width ≈12-14 μm, length ≈12-14 μm; elliptical valve, flat; setae relatively thin, curved, contain chloroplasts, arise from edge of valve. Forms curved chains, usually 8 cells, very narrow aperture. 1 chloroplast.

5.6 *Chaetoceros* sp. N. Width 3-5 μm, length 5-7 μm; elliptical valve, flat; setae arise in from edge of valve and turn abruptly as shown; setae long, straight or curved, in one plane. Cells single. 1 chloroplast.

5.7 *Chaetoceros* sp. O. Width 8.5 μm, length 8.5 μm; cf. *C. atlanticum* but no spine on valve.

5.8 *Chaetoceros* sp. P. Width 4-6 μm, length 2-3 μm; elliptical valve, concave; setae long, curly or straight, arise from edge of valve. Short chains, narrow aperture. 1 chloroplast. *C. karianum*?

5.9 *Chaetoceros filiforme*, as described in the literature but single cells also common.

5.10 *Chaetoceros perpusillum*, as described in the literature.

5.11 *Chaetoceros cf. densum*, but not quite as illustrated in the literature. 2 chloroplasts.

Figure 6

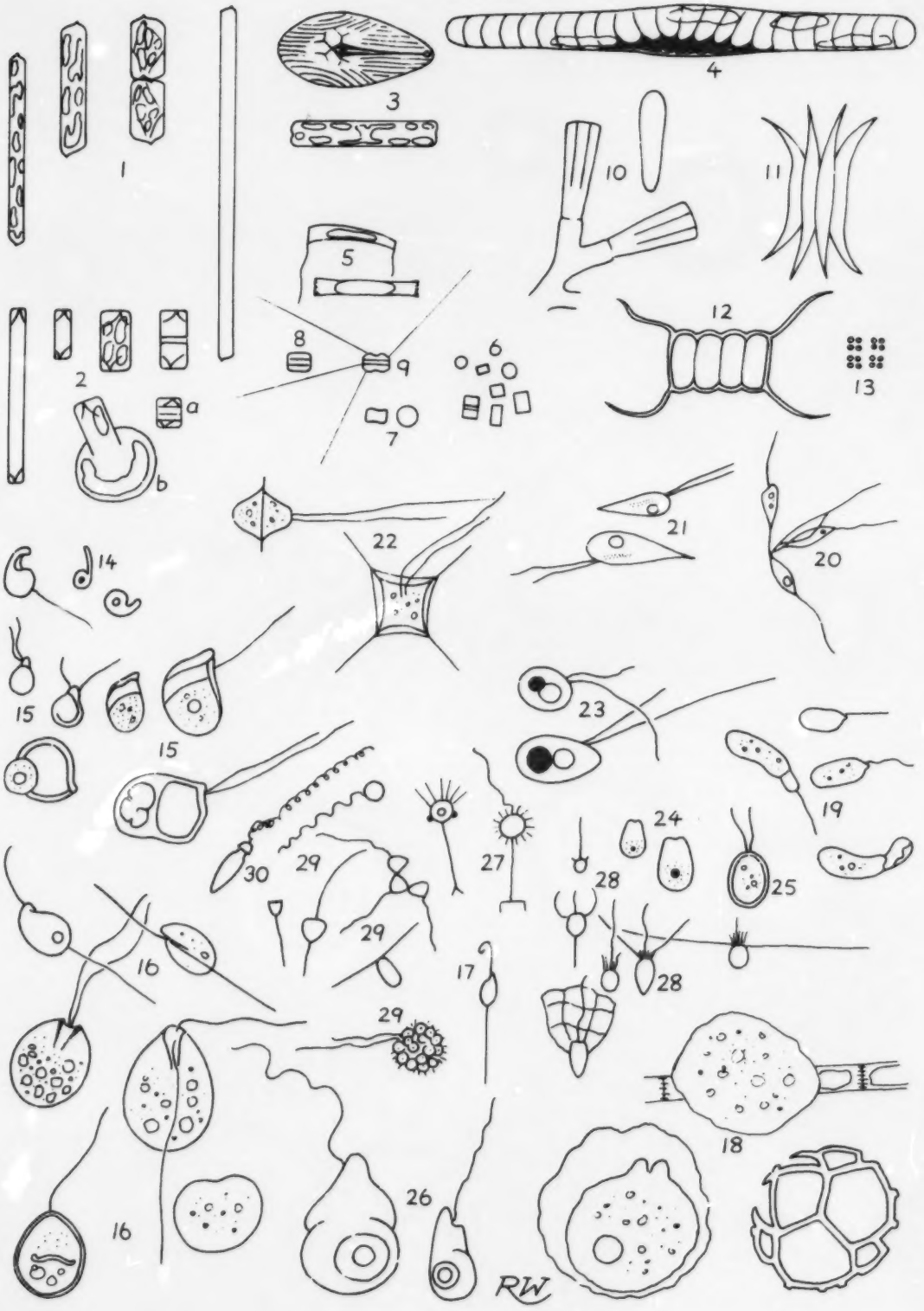
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FIGURE 6. Miscellaneous diatoms, heterotrophs and others.

6.1 *Rhizosolenia fragilissima* var. 1. Width 2.5-6 μm, length 11-61 μm.

6.2 Unidentified cylinders. Width 2.5-5 μm, length 2.5-30 μm. 2a: intercalary bands? 2b: auxospore.

6.3 *Asteromphalus* sp. 1. Length 23-30 μm.

6.4 *Rhizosolenia stolterfothi* spore.

6.5 *Minutocellus* sp. Width 3-36 μm, length 1.5-3 μm.

6.6 *Leyanella arenaria*. Width 2-3 μm, length 2-5 μm; but no detail visible. (See Figs. 10.5, 10.6)

6.7 *Cyclotella*? sp. Width 3-5 μm, length 2-7 μm.

6.8 *Cyclotella* sp. 2. Width 4-10 μm. (See Fig. 10.3)

6.9 *Thalassiosira conferta*. Note wide range of size, 3.5-23 μm diameter, and the characteristic threads. (See also Fig. 10.2)

6.10 *Licmophora* sp. 1. Length 14.5-30 μm.

6.11 *Scenedesmus acuminatus*. (freshwater)

6.12 *Scenedesmus quadricauda*. (freshwater)

6.13 *Merismopedia* sp. (freshwater)

6.14 *Rhynchomonas pusillus*. Length without proboscis 2.6-5 μm.

6.15 *Phacomonas pelagica* (Buchanan's *Entomosigma*). Length 6-15 μm. The largest cell has ingested a *Gymnodinium*.

6.16 Bodonid/*Anisonema* sp. 1. Length 10-23 μm. (Probably freshwater)

6.17 Bodonid/*Anisonema* sp. 2. Length 3-5 μm.

6.18 *Ebria tripartita* cell and skeleton; cell ingesting *Skeletonema*.

6.19 *Petalomonas* sp. Length 8.3-16.5 μm.

6.20 *Ochrostylon* sp. Length 8.4 μm.

6.21 *Chilomonas* sp. Length 11-18 μm.

6.22 Flagellate (ix). Length without spines 10 μm.

6.23 Flagellate (viii). Length 8.2-20 μm.

6.24 Flagellate (xvi). Length 7-10 μm. (Probably freshwater)

6.25 Flagellate (xiii). Length 10-12 μm. (Probably freshwater)

6.26 Flagellate sp. 4 (*Pronoctiluca*?). Length 15-20 μm (see also Fig. 7.29a).

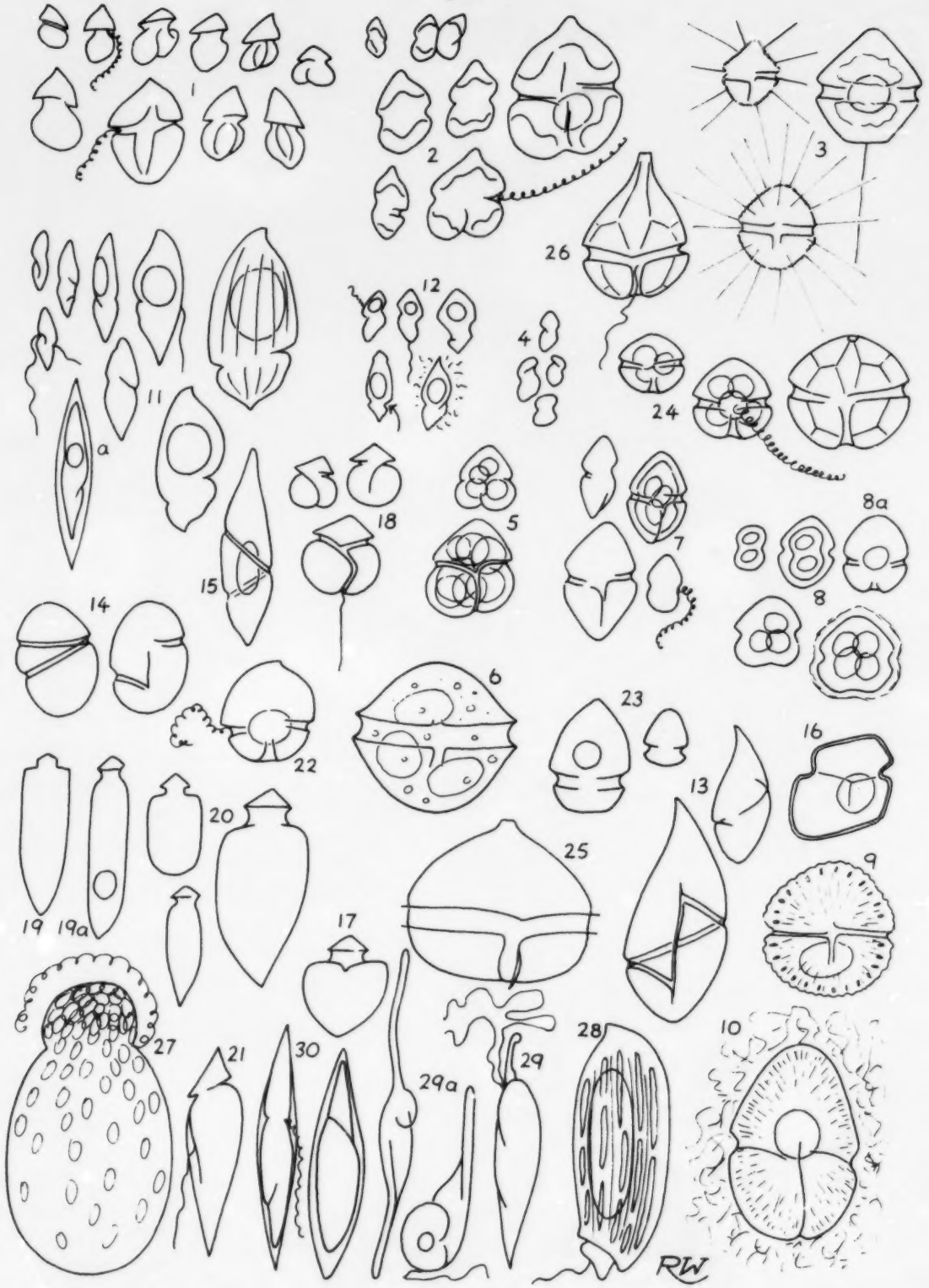
6.27 *Paraphysomonas* sp. 3.5-5 μm.

6.28 Choanoflagellates

6.29 Miscellaneous unidentified colourless flagellates.

6.30 Flagellate sp. 2

Figure 7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RW

FIGURE 7. Heterotrophic dinoflagellates.[2]

7.1 *Gymnodinium* sp. C. Length 8-20 μm.

7.2 *Gymnodinium* sp. W. Length 7-26 μm. In Lugol's the cell appears to have chloroplasts but it does not.

7.3 *Gymnodinium* sp. V. Length 11-20 μm; has trichocysts.

7.4 *Gymnodinium* spp. Length 6-10 μm.

7.5 *Gymnodinium* sp. N [= Buchanan's (1966) *Gyrodinium* sp. 3, plate VII, fig. 8]. Length 12-18 μm. Similar to *Gyrodinium metum* Hulburt. West coast.

7.6 *Gymnodinium lazulum* Hulburt. Length 21-26 μm.

7.7 *Gymnodinium* sp. O. Length 13-23 μm; has a "theca." Cell contains 2-4 brown-staining masses.

7.8 *Gymnodinium* sp. H. Length 8.2-18 μm; has a "theca." Cell contains 2-4 dark-staining masses. 8a: live cell.

7.9 *Gymnodinium* sp. G. Length 14-23 μm; has rhabdosomes. Cytoplasm has radial structure.

7.10 *Gymnodinium stellatum* Hulburt. Length (18-)25-40(-70) μm; has trichocysts and "radial cytoplasm".

7.11 *Gyrodinium* cf. *glaucum* but smaller and less torsion [= Buchanan's (1966) *Gyrodinium* sp. 1, plate VII, figs. 5-7]. Length 10-33 μm. 11a: cyst? 14-23 μm

7.12 *Gyrodinium*? sp. E. Length 8.4-12.6 μm. Phagotrophic; cell ingests food as shown .

7.13 *Gyrodinium cf. lachryma* (= "*G. biconicum*" optically reversed), but length is only 13.2-86 μm, usually 40 μm. Dodge (1982) gives length of *G. lachryma* as 80-105 μm. Cells can be squat with a rounded hypocone (cf. *G. pepo*, when viewed through the cell or when image is optically reversed[3]--a hazard to be aware of with dinoflagellates.)

7.14 *Gyrodinium lebourae*? Length 18-24 μm.

7.15 *Gyrodinium fusiforme* (side view), but length is 26-80 μm, usually 30-50 μm. Dodge gives it as 50-125 μm.

7.16 Thecate sp. T. Length 21 μm. At P5-P.

7.17 *Amphidinium turbo*. Length 18-23 μm. P5-P.

7.18 *Amphidinium* sp. Y. Length 9-15 μm.

7.19 *Amphidinium lanceolatum*. Length 30-33 μm. Also 19a? West coast.

7.20 *Amphidinium longum*. Length 18-36 μm. Also 19a? This seems too variable for one species yet all these forms are presented as *A. longum* in the literature.

7.21 *Amphidinium sphenoides*. Length 35-42 μm.

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[2]Many of these stain darkly in Lugol's iodine and give a false impression of the presence of chloroplasts.

[3]Some inverted microscopes, for instance the Leitz Diavert, produce a reversed image.

7.22 *Katodinium asymmetricum.* Length 14-22 μm. West coast.

7.23 *Glenodinium inaequale.* Length 9.5-23 μm.

7.24 *Glenodinium* sp. M. Length 10-20 μm. Cell contains 2-4 dark staining masses.

7.25 *Glenodinium pilula* as in Buchanan(1966), plate XII fig. 5.

7.26 Peridiniaceae sp. S. Length 25-40 μm.

7.27 *Noctiluca scintillans* swarmer.

7.28 *Torodinium robustum.* Length 36-75 μm. West coast and P1-P.

7.29 *Pronoctiluca pelagica.* Length 12-45 μm. Also 29a? West coast, P1-4.

7.30 Assorted spindle-shaped cysts. Length 30-46 μm. Also 11a. (*P. pelagica, A. sphenoides, Gyrodinium*?)

Figure 8

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FIGURE 8. Phototrophic dinoflagellates.

8.1 *Gymnodinium vitiligo*. Length 10-17.5 μm. Brownish yellow. May include *Gyrodinium estuariale* Hulburt. Spins round while swimming straight forward.

8.2 *Gymnodinium simplex*. Length 5-12 μm. Red. Darts, jerks about, swimming is fast and erratic.

8.3 *Gymnodinium cf. flavum*, as in Wailes (1939). Length (16-)18-28(-30) μm. Yellow discoidal chloroplasts.

8.4 *Gymnodinium gracilentum*. Length (6-)8-12(-27) μm. Brown. Displaced girdle and an extremely long transverse flagellum. Cells sometimes enclosed in a "theca."

8.5 *Gymnodinium paulseni*. Length 10-24 μm. Brown. Can be confused with *G. gracilentum*. West coast, P1-P.

8.6 *Gymnodinium gelbum*. Length 31-50 μm. Many yellow discoidal chloroplasts. Live cell. West coast, P1-P.

8.7 *Gymnodinium splendens*. Length 40-50 μm. Brown. West coast, P1-P.

8.8 *Gymnodinium cf. aureolum*, but too small? Length 12-26 μm. Numerous yellow-brown chloroplasts. A bloom former (1.1×10^7 L^{-1} recorded in May, 1973, 49°20'N 134°40'W). May be confused with UBC sp. 94 in preserved material.

8.9 *Gymnodinium* sp. (UBC sp. 94). Length 12-23 μm. Numerous red-brown chloroplasts. Very slightly flattened. West coast, P1-P.

8.10 *Gymnodinium* sp. (UBC sp. 176). Length (10-)15-20 μm. Many brown chloroplasts arranged in radial fashion. Flattened. Jerky, irregular motion.

8.11 *Gymnodinium* swarmer. Length 6 μm.

8.12 *Gymnodinium* sp. R. Length 6.6-9.9 μm. Several yellow-brown chloroplasts. Fast moving. West coast, P1-P.

8.13 *Gymnodinium* sp. (UBC sp. 246). Length 13-16 μm. Several brown chloroplasts. Much flattened with a prominent sulcus. Cell turns over and over when swimming. P5-P.

8.14 *Aureodinium pigmentosum*. Length (8-)10-14(-18) μm. Red. Sometimes seen with outer layers around the cell, as in 14a.

8.15 *"Gonyaulax" rugosum*. Length 21-32 μm. 15a: live cell, ¼ view. The cell is rather flattened. A few scattered, pale brown chloroplasts, numerous oil droplets and starch grains, nucleus central to posterior; cell is athecate with a bubbly amphiesma. Five or more tubular trichocysts with forked tips are ejected by highly stressed cells (length 30-250 μm, width 3-8 μm when viewed as illustrated). Fig. 15 shows the cell shape prior to expulsion of trichocysts. In reality the cell is collapsed in this situation, though the bubbles are still evident.

8.16 *Gyrodinium prunus* (after Drebes). Length ≈40 μm. Brown. Live cell. P5-P.

8.17 *Cochlodinium citron*. Length 37-49 μm. Brown. Toxic to fish. Forms occasional blooms on the west coast of Vancouver Island.

8.18 *Amphidinium* sp. M. Length 15.5-18 μm. Brown. Swims with a fast forward swivelling motion. P5-P.

8.19 *Amphidinium corpulentum*. Length ≈34 μm. Brown. Live cell. P1-4.

8.20 *Amphidinium carterae*. Length 18 μm. Brown.

8.21 *Amphidinium klebsii* as in Lebour (1925). Length 33 μm. Yellow.

8.22 *Amphidinium* sp. Length 24-26 μm. Live cell. Similar in size and shape to *A. stigmaticum*, but yellow-brown. Confusable in Lugol's. P1-4.

8.23 *Katodinium rotundatum*. Length 9-14 μm. Yellow-brown. Not exactly as described in Lebour (1925). Smaller cells in preserved samples sometimes appear far less robust and less sharply defined than at other times.

8.24 *Scrippsiella*? sp. U. Length 9.45-13.5 μm. Not seen live. May not be photosynthetic.

8.25 *Alexandrium ostenfeldii (Goniodoma)*. Length 40-46 μm. Toxic. Forms occasional blooms offshore to the west of Vancouver Island.

8.26 *Dinophysis schröderi*? Length ≈75 μm. Red. The sulcal list is not as illustrated in published descriptions of *D. schröderi*.

8.27 *Dinophysis parva*? Length ≈35 μm. Similar to *D. parva* as illustrated in Wailes (1939) but smaller and with a deeper anterior "funnel."

8.28 *Prorocentrum oblongum* or *aporum*? (not Wailes' *E. apora*) Length ≈30 μm.[1]

8.29 *Prorocentrum* sp. Length 23 μm. P1-P (also in Taylor, 1976).

8.30 *Prorocentrum* sp. Length 16.4-18 μm. Brown. P1-P (also in Taylor, 1976).

8.31 *Prorocentrum nanum*. Length 16-21 μm. West coast, P1-P.[1]

8.32 *Prorocentrum maximum*. Length 19-22 μm. West coast.

8.33 *Prorocentrum vaginula*. Length 21 μm. West coast, P1-P.

8.34 *Prorocentrum balticum*. Length 9-14 μm. West coast, P1-P.[1]

8.35 *Prorocentrum minimum*. Length 14-22 μm. West coast.[1] It is doubted, but not clearly recalled, whether a clonal culture of *P. minimum* from a local isolate contained cells of the size and shape of fig. 35a. Such cells were not often seen in the IOS samples. Dodge (1982) includes it under *P. minimum* so there may be clonal variations.

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[1]The anterior spine(s) is/are not always visible under light microscope.

Figure 9

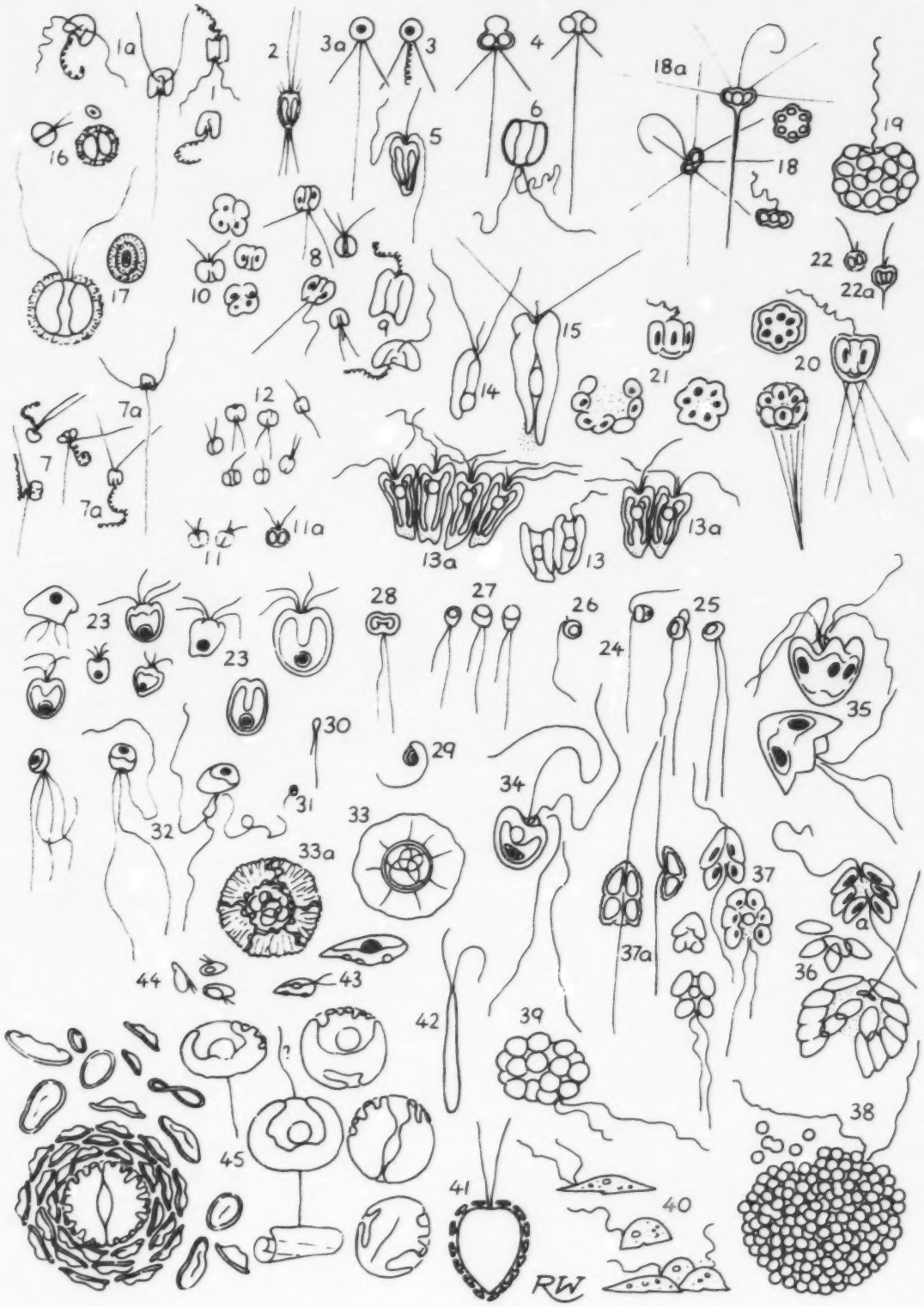
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FIGURE 9. Miscellaneous phototrophs.

9.1 *Chrysochromulina* sp. (saddle-shaped). 4-5.5 μm. 1a: live cells.

9.2 *Chrysochromulina mantoniae.*

9.3 *Chrysochromulina* sp. 7. 3a: live cell.

9.4 *Chrysochromulina* sp. 2, live cells.

9.5 *Chrysochromulina polylepis.* Live cell.

9.6 *Chrysochromulina leadbeateri.*

9.7 *Chrysochromulina* sp. 1 (UBC sp. 63). 2.5-3.5 μm. 7a: live cells. (see Figs. 12.3, 12.4)

9.8 *Chrysochromulina* spp. (round, includes *C. minor* and UBC sp. 28). 3-6 μm. Scales of UBC sp. 28 are shown in Fig. 12.5 and Hallegraeff (1983).

9.9 *Chrysochromulina* spp. (saddle-shaped, includes *C. cymbium* and *C. ephippium*). 6-10 μm.

9.10 *Phaeocystis pouchetii.*

9.11 *Phaeocystis* sp. (UBC sp. 224). 2.5-3.5 μm. 11a: live cell. (see Figs. 11.5, 12.1, 12.2) Booth (pers. comm.) finds high numbers of this species in subarctic samples. Scales cf. *P. scrobiculata* (Moestrup, 1979).

9.12 *Imantonia rotunda.* May include small cells of *Dicrateria inornata.*

9.13 *Corymbellus* sp. (Plymouth sp. 115 "Twins"). 11-13 μm. 13a: live cells. (see also Fig. 12.6)

9.14 *Prymnesium* sp. (Buchanan's sp. 1). 11-17 μm.[1]

9.15 *Prymnesium* sp. 16-25 μm.[1]

9.16 *Emiliana huxleyi.* Motile cell; coccolith covered cell; coccolith.

9.17 *Crystallolithus hyalinus* and *Coccolithus pelagicus* coccolith. For pictures of coccolith-covered cells, see Parke & Adams (1960).

9.18 Pedinellacean sp. (UBC sp. 223). 2.5-3.5 μm. 18a: live cells. (see Fig. 11.6)

9.19 Pedinellacean sp. (UBC sp. 239, Plymouth sp. 323).[2] 12-18 μm; live cell. Multiple yellow chloroplasts.

9.20 *Apedinella spinifera.*

9.21 *Pseudopedinella pyriformis.*

9.22 *Ochromonas* sp. (UBC sp. 190). 2.5-3.5 μm. 22a: live cell. One yellow chloroplast. Like *O. crenata* Klebs but too small.

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[1]May be toxic to fish. For fuller details and descriptions see Aquaculture Association of B.C. Newsletter final issue (1992).

[2]Preparation for ultrastructural examination has so far been hampered by the collapse of the cells upon fixation.

9.23 *Pyramimonas* (4-lobed) and *Platymonas* (bilobed) spp. 3-14.2 μm.

9.24 *Nephroselmis longifilis*? 3 μm.

9.25 *Nephroselmis*? sp. 3.5 μm.

9.26 *Bipedinomonas caeca*? 2.5-3 μm.

9.27 *Bipedinomonas* or *Nephroselmis semiglobata* and/or *pyriformis*? 3-5 μm.

9.28 *Bipedinomonas*? sp. 3.5-5 μm.

9.29 *Mantoniella squamata*. 3-4 μm.

9.30 *Pseudoscourfeldia marina*. ≈2.5 μm.

9.31 *Micromonas pusilla*? ≈1.5 μm.

9.32 *Pterosperma* and *Pachysphaera* spp. 4-10 μm. Non-motile phycomata (cysts) are winged (*Pterosperma*) or plain (*Pachysphaera*) spheres, total width (10[immature]-)35-250 μm. See Parke *et al.* (1978) and Parke (1966).

9.33 *Pterosperma* spp. Young phycomata, single and multiwinged types.

9.34 *Cymbomonas* sp. [*C. adriatica*?] (UBC sp. 130b). 9-11 μm; scales as for *C. tetramitriformis* (Throndsen, 1988), but with a possible fifth type of scale, rounded and similar to one found in *Halosphaera*. Unlike *C. tetramitriformis*, this species is easily cultured. Also in Plymouth collection.

9.35 *Halosphaera* spp. The phycomata are plain spheres, diameter (20[immature]-)200-800 μm. Empty walls of *Halosphaera* (and *Pachysphaera*) in the plankton resemble split, collapsed or folded plastic balls. See Parke & den Hartog-Adams (1965) and Boalch & Mommaerts (1969).

9.36 Raphidophyte 1. 10-20 μm; roughly a triangular shape, dorsoventrally flattened, 6-12+ yellow-brown chloroplasts, many prominent peripheral extrusomes. 36a: pyrenoids visible in a higher concentration of Lugol's.[1,2]

9.37 Raphidophyte 2. 8-12 μm; a small, slimmer version of Raphidophyte 1, but a distinct entity, at one time in clonal culture; 4-6 yellow-brown chloroplasts. The swimming action is a smooth glide while turning over slowly, flagella held almost straight, one extended forwards and the other one trailing. 37a: live cells.[1,2]

9.38 *Chattonella*? sp. 30-55 μm, down to 18 μm in the non-motile stage. Cells naked, globular, ovoid-obovoid or oblong and cylindrical, highly metabolic, having the capacity to change their shape and volume in an amoeboid fashion; numerous ≈2-3 μm gold chloroplasts and minute peripheral lipid globules; 2 heterodynamic flagella, approximately the length of the cell, are inserted in a deep anterior depression, one of them trailing posteriorly. Many little threads are expelled from lysing cells. Found mainly in cool (10-15°C) brackish waters of the B.C. coast.[1]

9.39 *Heterosigma akashiwo*.

9.40 *Solenicola setigera*. 6-20 μm.

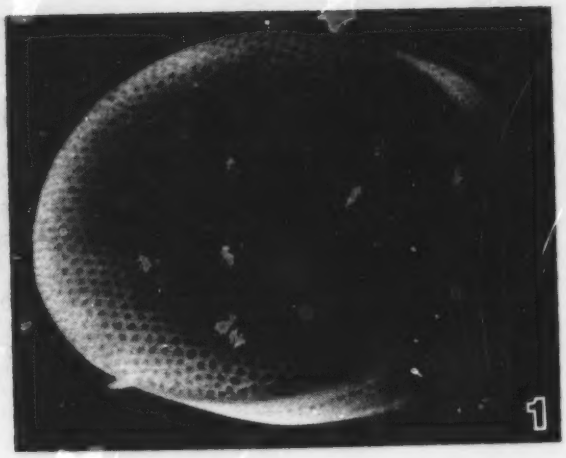
9.41 Flagellate 19. 16 μm. (Colour and contents unknown.)

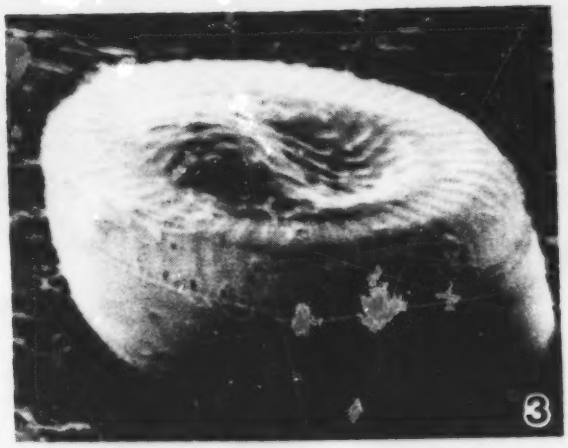
9.42 *Eutreptiella* sp. 18-28 μm. (Pale, contents unseen.)

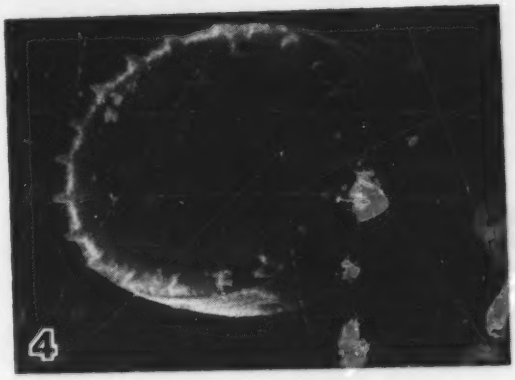
9.43 *Cryptomonas* spp. (red), 9-17 μm; *Plagioselmis*? sp. (brown), 6-9 μm.

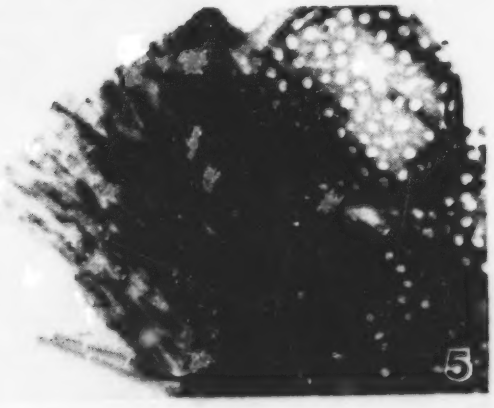
9.44 *Hemiselmis* spp. (pink). 4-8.5 μm.

9.45 *Pseudorocella?* sp. (Deflandre, 1938). This is an interesting and puzzling genus at present. Cells were isolated from a 3 m water sample collected at station P5 in August, 1977, and successfully cultured in ESNW at 15°C. The cells had a single cup-shaped, bilobed, yellow chloroplast enclosing the nucleus, and their length, excluding scales, was 9.4-16.4 μm. Except at their posterior pole the cells had a covering of usually 3 layers of loose scales, circular to elliptical in outline and shaped like a shallow, brimmed hat, with a raised rim and a perforated crown. Within a clonal culture, the scale length ranged from 3.5-11.7 μm and the perforations varied in size and shape, both being smaller than those of *P. barbadiensis* as represented in Perch-Nielsen's (1978) photographs. The scales (Fig. 12.7a) did not dissolve in dilute HCl, but seemed to have partially eroded following the addition of Na_2SiF_6 (Fig. 12.7b). The cell had a posterior attachment thread and a doubtful flagellum, seen only fleetingly at the opposite pole. The cells were not seen to be motile, apparently remaining attached to crystals of silica, as shown. They underwent binary fission *in situ*. The figure shows live cells, the scales omitted from all but one in which the layers are shown in cross section only. Very similar scale-covered cells and free scales have been found by B.C. Booth, H.A. Thomsen and C. Kosman in several locations, including North African and Mexican seas (pers. comm.).









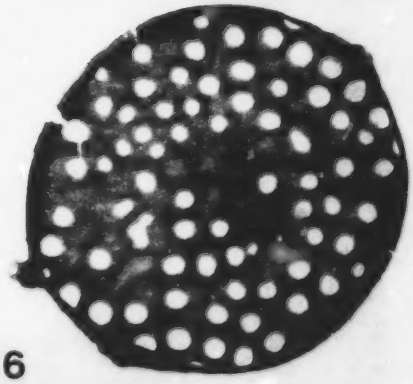


Figure 10

FIGURE 10. Electron micrographs of centric diatoms from Esquimalt Lagoon and B.C. coastal waters. 10.1 - 10.4 by B.D. Hall; 10.5 & 10.6 by S. Stanton, courtesy of B. Booth.

10.1 *Thalassiosira* sp. 1, SEM x5000.

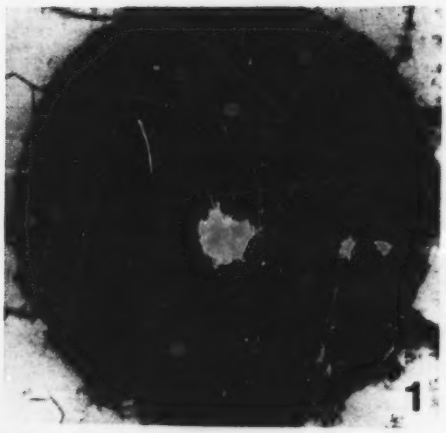
10.2 *T. conferta*, SEM x7500.

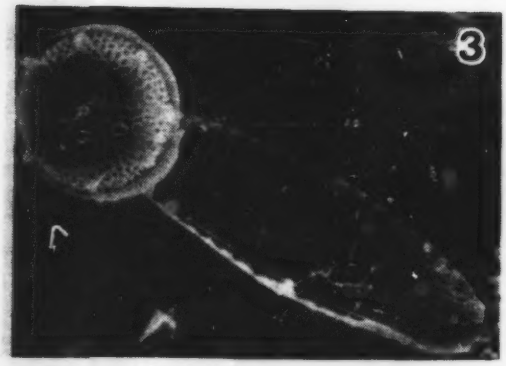
10.3 *Cyclotella* sp. 2, SEM x7500.

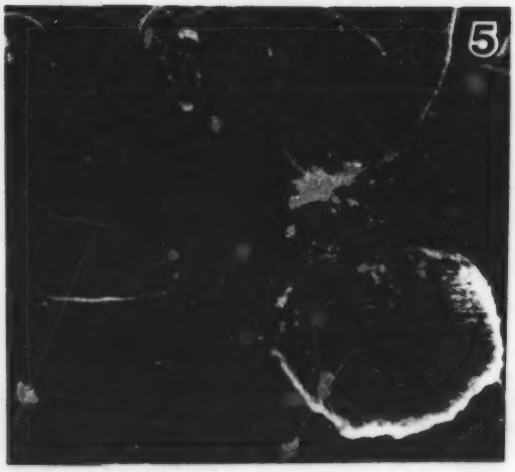
10.4 *Thalassiosira guillardii*, SEM x6500.

10.5 *Leyanella arenaria*, TEM x11 667.

10.6 *L. arenaria*, TEM x23 333.







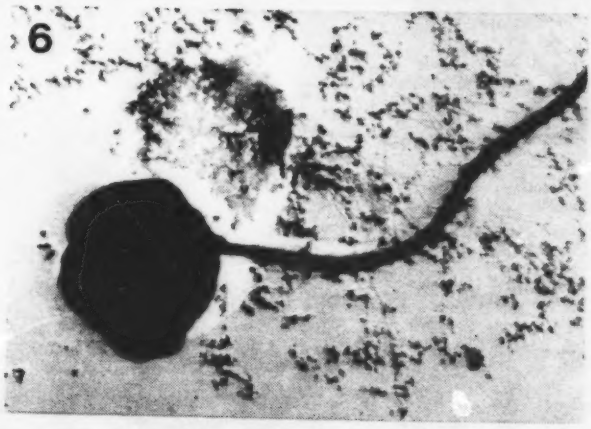


Figure 11

FIGURE 11. Electron micrographs of diatoms and flagellates from Esquimalt Lagoon and B.C. coastal waters. 11.1 courtesy of F.E. Round; 11.2-11.4 by B.D. Hall; 11.5 & 11.6 by S. Stanton, courtesy of B. Booth.

11.1 *Thalassiosira pseudonana*, TEM x8500.

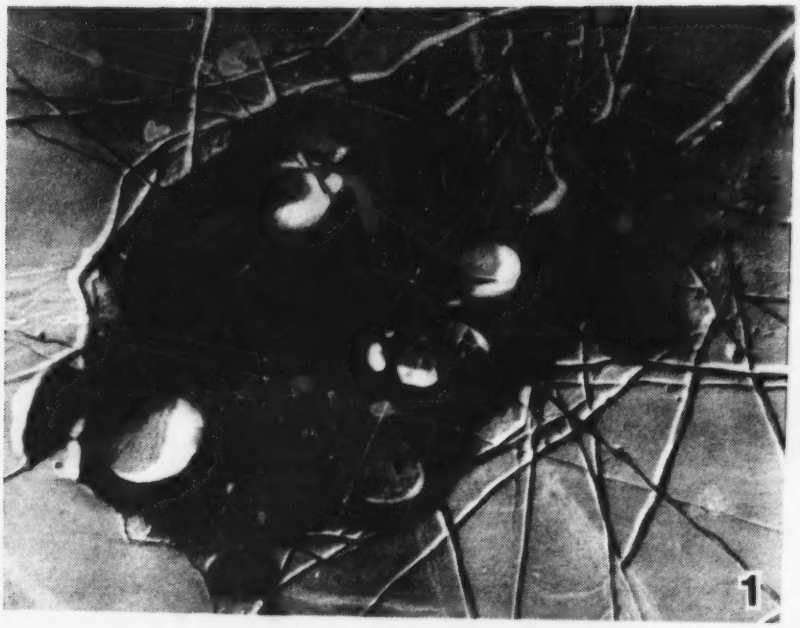
11.2 *Navicula* sp. 1, SEM x3000.

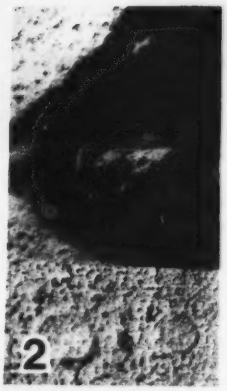
11.3 *Stauroneis*? sp. (with *Thalassiosira conferta*), SEM x6500.

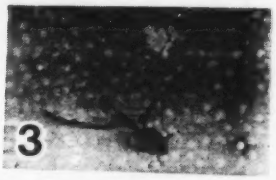
11.4 *Navicula* sp. 2, SEM x4300.

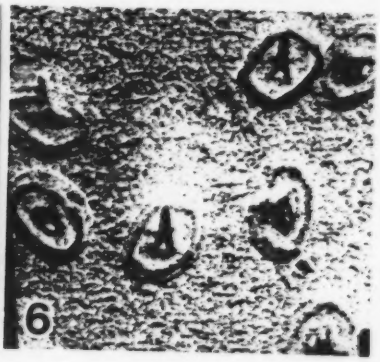
11.5 *Phaeocystis* sp. 224, SEM x12 500.

11.6 Pedinellacean sp. 223, TEM x11 667. The flagellar hairs split up into several fine hairs at a point 2/3 of the way from the proximal end.









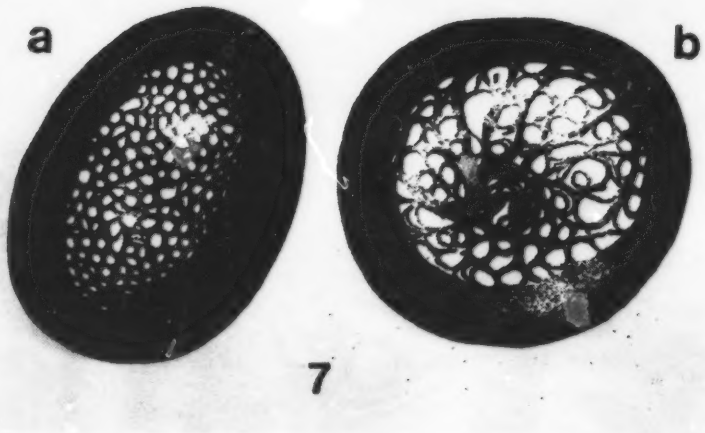


Figure 12

FIGURE 12. Electron micrographs of flagellates from Esquimalt Lagoon and B.C. coastal waters. 12.1 by S. Stanton, courtesy of B. Booth; 12.2-12.7 courtesy of F.J.R. Taylor.

12.1 *Phaeocystis* sp. 224, showing flagellar threads, TEM x12 333.

12.2 *Phaeocystis* sp. 224 scales (two types), TEM x40 000.

12.3 *Chrysochromulina* sp. 1, TEM x1750.

12.4 *Chrysochromulina* sp. 1, showing scales, TEM x19 000.

12.5 *Chrysochromulina* sp. 28 scales (one side only, the reverse side being smooth and unsculptured), TEM x40 000.

12.6 *Corymbellus* sp. scales, TEM x40 000.

12.7 *Pseudorocella*? sp. scales, TEM x6 600. a, oval scale; b, circular scale, partially eroded?